PRA170

Nouvelle Série, Tome XI, Fasc. 3-4 1976

REVUE ALGOLOGIQUE

LABORATOIRE DE CRYPTOGAMIE
MUSÉUM NATIONAL D'HISTOIRE NATURELLE
12, RUE DE BUFFON - 75005 PARIS

Publication Trimestrielle *Sorti des presses le 20 janvier 1977*

Nouvelle Série, Tome XI, Fasc. 3-4 1976

REVUE ALGOLOGIQUE

Fondée en 1922 par P. ALLORGE et G. HAMEL

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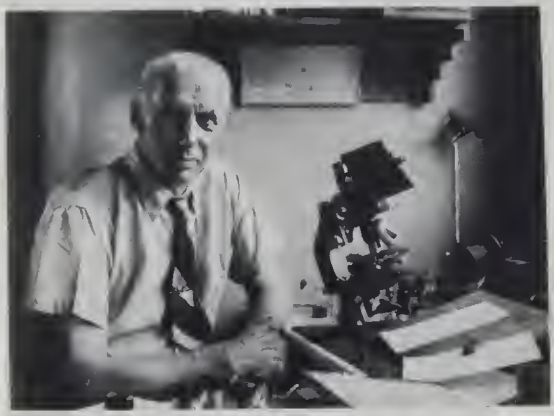
EINAR TEILING (1888-1974) *

P. BOURRELLY

Le 21 août 1974, Einar TEILING, le doyen des algologues d'eau douce, s'est éteint doucement à Lund, à l'âge de 86 ans.



Il était né le 21 mars 1888 à Stockholm où il prépara à l'Université, de 1907 à 1917, la licence de Sciences Naturelles. A cette époque, tout en continuant ses études, il enseignait à l'école Beskow de 1908 à 1919; il acheta alors son

* Je remercie très vivement mon ami, le Dr. K. THOMASSON, de l'Université d'Uppsala, de m'avoir fourni les documents nécessaires à la rédaction de cette notice (voir THOMASSON, 1975, *Sv. Bot. Tidskr.* 69 : 191-197.

Rev. Algol., N. S., 1976, XI, 3-4 : 205-208.

Source MNHN Paris

premier microscope et s'intéressa vivement à la géologie et à l'algologie des eaux douces. Il fut, à l'Université, l'élève du Prof. G. LAGERHEIM.

Son intérêt passionné pour les algues le mit en relation avec le grand desmidiologue O. BORGE. Celui-ci lui ouvrit largement sa riche bibliothèque et sa collection de dessins algologiques. Le jeune TEILING, qui était excellent dessinateur, comprit l'importance capitale de la documentation et commença alors à se constituer une iconothèque et une bibliothèque spécialisée.

Ces collections ont été léguées à la section algologique de l'Université d'Uppsala. Le Dr. TEILING était avant tout un homme de «terrain» et ses vacances se passaient à récolter des algues planctoniques des innombrables lacs suédois. Dès 1912 il put ainsi publier sa première note sur le Phytoplancton d'un lac proche de Stockholm. En 1916, une nouvelle note suivra où il décrira le nouveau genre de Chlorococcale : *Tetrallantos*.

Au début de la première guerre mondiale il travaille pendant un mois dans le laboratoire du Prof. KOLKWITZ à Berlin et se familiarise ainsi avec la notion des algues indicatrices de pollution.

En 1916 il publia, sur les conseils de WESENBERG qu'il a visité en 1913, une étude sur la formation phytoplanctonique qu'il appelle «calédonienne» (comparable à celle trouvée par W. et G. S. WEST en Ecosse) et l'oppose à une formation «baltique». Ces formations, floristiquement très différentes, se retrouvent dans des lacs voisins mais se distinguent par leur âge géologique, leur sous-sol, et leur environnement. Ce travail, écrit en suédois, resta malheureusement inconnu hors de Suède. Cela est fort regrettable, car il contenait en germe la distinction fondamentale entre plancton d'eau pauvre en éléments nutritifs (calédonien) et plancton d'eau riche en substances dissoutes (baltique). C'est ce que NAUMANN en 1919, appellera milieu oligotrophe et milieu eutrophe.

TEILING, cependant, insistait davantage non sur la productivité mais sur l'aspect qualitatif du phytoplancton.

Sa licence terminée TEILING est nommé professeur à l'École Normale de Strängnäs (1919-1931) puis à Växsjö (1931-1937) et enfin à Linköping (1937-1953). Il va ainsi pendant 25 années se consacrer uniquement à l'enseignement. Mais en 1940, le Prof. G. E. DU RIETZ, ayant retrouvé *Tetrallantos* dans un lac voisin d'Uppsala, entre en relation avec le Dr. TEILING, lui demande confirmation de ses déterminations d'algues et l'encourage à reprendre ses travaux de recherches. TEILING étudie alors avec soin le phytoplancton de plus de 600 lacs suédois et publiera jusqu'en 1967 une série de notes et de mémoires qui font autorité. Il se penche particulièrement sur la morphologie des chloroplastes des Desmidiées, et montre son importance tant pour la taxinomie que pour la phylogénie. Il arrive ainsi par des voies différentes à des conclusions voisines de celles de CHADEFAUD sur l'évolution des plastes.

Ses études sur le polymorphisme de ces algues lui permettent de ressusciter le genre *Actinotaenium* et de créer le nouveau genre *Staurodesmus*. Ce dernier taxon groupe, en une synthèse intelligente, des formes bipolaires et multipo-

Source MNHN, Paris

laires que la systématique classique séparait sous des noms de genres différents tels que *Staurastrum* et *Arthrodesmus*. Ce genre *Staurodesmus* créé par TEILING en 1948 a fait l'objet en 1967 d'une monographie qui restera comme un modèle de clarté et de logique.

La grande activité scientifique de E. TEILING est enfin reconnue officiellement et de 1945 à 1958 il est chargé de cours d'écologie et de taxinomie du phytoplancton à l'Institut Limnologique de l'Université de Lund et au Laboratoire d'Aneboda. Enfin en 1950, il reçoit la distinction suprême de Docteur honoris causa de l'Université de Lund.

En 1960, il s'installe à Lund mais garde des liens étroits avec l'Université d'Uppsala. Malgré son âge avancé, il demeure le conseiller des jeunes algologues (et même des «moins jeunes») et sa bibliothèque et sa vaste érudition sont à la disposition de tous les chercheurs.

Il ne faudrait pas croire que l'enseignement et l'algologie suffisaient à remplir la vie de E. TEILING. Il adhérait à de nombreuses sociétés savantes et fut le doyen des membres de la société botanique suédoise. De plus, grand amateur de musique, il avait participé à la fondation de la Société de Musique de Stockholm; il était aussi membre d'un club automobile et d'une société de photographie dont il était le fondateur.

Ce grand algologue dont nous venons de retracer brièvement la vie nous laisse le souvenir d'un esprit curieux, amateur et observateur passionné de la nature et de ses secrets, et en même temps ouvert aux côtés humains de l'existence.

Ainsi tous ceux qui l'ont approché ont apprécié sa grande culture, sa bonté souriante, sa simplicité, son esprit plein d'humour et d'indulgence.

Je le connaissais personnellement depuis 25 ans et ses conseils et son amitié ne m'ont jamais fait défaut. Je me souviens toujours avec émotion du jour de ma soutenance de thèse où je reçus de Suède, avec une lettre de félicitation, une gerbe de fleurs de sa part. Ce geste montre toute la délicatesse de son amitié.

L'algologie a perdu avec le Dr. TEILING, un de ses maîtres, et moi un ami très cher.

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Source MNHN, Paris

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1967 — The desmid genus *Staurodesmus*. A taxonomic study. *Ark. bot., Ser.* 2, 6 : 467-629.

Source MNHN, Paris

Georges DEFLANDRE (1897-1973)

Y. LE CALVEZ

Georges, Victor DEFLANDRE naquit à Dizy-Magenta (Marne) le 18 mars 1897. Il reçut de son père artiste-peintre et cheminot, de son grand-père paternel organiste et compositeur ses dons artistiques : il dessinait fort bien et, excellent musicien, jouait indifféremment de l'orgue et de l'harmonium, du piano et du clavecin, du violon et du violoncelle. De son grand-père maternel, inventeur

d'une horloge électrique et artisan du premier wagon-dynamomètre construit en France, il hérita ses qualités d'observation, son amour de la recherche, son goût de la découverte.

Obligé en 1913 d'interrompre ses études secondaires brillamment commencées, il devint employé du Chemin de fer, puis en 1915 instituteur. Mobilisé en

Rev. Algol., N. S., 1976, XI, 3-4 : 209-211.

Source MNHN Paris

1916, Georges DEFLANDRE, d'abord Aspirant, puis Sous-Lieutenant d'Infanterie, fut blessé et fait prisonnier en 1918. A son retour de captivité, il retrouve son poste d'instituteur mais, désireux d'accroître ses connaissances scientifiques, il reprend seul ses études et commence dès 1922 à fréquenter assidûment le Laboratoire de Cryptogamie du Museum, dirigé par L. MANGIN. Tout le temps que lui laisse ses obligations professionnelles, il le consacre à la recherche et, en 1926, il soutient sa thèse de Doctorat d'Université. Nommé en 1930 préparateur à l'École Pratique des Hautes Études dans le Laboratoire de L. MANGIN, il est en 1932 boursier à la Caisse Nationale des Sciences et accueilli au Laboratoire d'Évolution des Etres Organisés. En 1943, l'École Pratique des Hautes Études créait pour lui le Laboratoire de Micropaléontologie qu'il devait diriger jusqu'en 1967, et le C.N.R.S. lui conférait en 1953 le titre de Directeur de Recherche. Plusieurs fois Lauréat de l'Académie des Sciences, Président de la Société Française de Microscopie (1933), Fondateur et Directeur des Annales de Protistologie (1928-1936), G. DEFLANDRE était membre d'Honneur de nombreuses sociétés tant françaises qu'étrangères, Correspondant de l'Académie des Sciences et Chevalier de la Légion d'Honneur.

L'œuvre scientifique de G. DEFLANDRE est immense et couvre l'ensemble de la Micropaléontologie et de la Protistologie. Il n'est pas possible ici d'analyser tous ses travaux, aussi me bornerai-je à donner un très bref aperçu de l'essentiel de ses recherches consacrées aux Algues.

Lorsqu'en 1920 il commença à s'intéresser aux Algues microscopiques unicellulaires des eaux douces, ce groupe était très délaissé et de nombreuses régions de France restaient encore à explorer. G. DEFLANDRE en quelques années apporta une contribution notable à la floristique de la France en publiant une série de notes relatives d'abord aux environs de Paris, puis à la Basse Normandie, enfin à la Bretagne, aux Vosges, aux Pyrénées et aux Ardennes. Au point de vue morphologique et systématique, les Desmidiées tiennent une large place dans ses recherches mais il ne néglige pas pour autant les autres Chlorophycées.

Puis, pendant de nombreuses années, G. DEFLANDRE va consacrer une grande partie de son activité à l'étude des Flagellés. Ses premiers travaux se rapportent aux Phytoflagellés et principalement aux Eugléniens dont il étudie la morphologie et la cytologie : sa monographie du genre *Trachelomonas* sera le sujet de sa thèse et en 1959, il signalera l'existence des premiers *Trachelomonas* fossiles dans un schiste bitumineux du Pliocène de Madagascar. Il se penche ensuite sur les Silicoflagellés ou Flagellés siliceux et établit une nouvelle classification des Chrysomonadines, créant pour 65 d'entre elles la famille des Archaeomonadacées. Il s'intéresse aussi aux Ebriidés et publie de nombreux articles concernant leur morphologie et leurs tendances évolutives.

C'est en 1939 qu'il commence ses observations sur les Flagellés calcaires, avec celles des Coccolithophoridés, aujourd'hui très étudiés, mais qui ne comptaient alors qu'un petit nombre de spécialistes. Là encore, il crée de nombreux genres, espèces et la famille des Braarudosphéridés.

Dans le même temps, son intérêt se porte sur les microfossiles des silex cré-

Source MNHN Paris

tacés (Dinoflagellés, Hystrichosphéridés, etc.) et sur les Diatomées.

Tous ces travaux ont abouti à plus de trois cents publications, écrites dans un style précis, clair, élégant et illustrées de dessins qu'il exécuta lui-même ou de photographies dont il était l'auteur.

A côté de ces recherches originales qui ont fait de lui le grand précurseur de la Micropaléontologie moderne, G. DEFLANDRE est l'auteur d'ouvrages de vulgarisation qui ont largement contribué à faire connaître l'existence des micro-organismes : «La microscopie pratique» parue en 1930 et la «La vie créatrice des Roches» publiée en 1941, traduite dans toutes les langues et dont la dernière édition date de 1967.

Dans le traité de Zoologie (Directeur P. P. GRASSÉ), G. DEFLANDRE rédigea les chapitres relatifs aux Phytomonadines, aux Xanthomonadines, aux Ebriédiens, aux Silicoflagellés, aux Chrysomonadines fossiles, aux Coccolithophoridés, aux Flagellés fossiles *incertae sedis*. Enfin, en collaboration avec Mme Marthe DEFLANDRE-RIGAUD, sa femme, il publia au C.N.R.S. le Fichier Micropaléontologique Général concernant tous les groupes de Protistes, et qui contient plus de 4000 fiches se rapportant aux seules Algues.

Cet autodidacte, qui était à la fois Algologue, Protistologue, et Micropaléontologiste, et qui embrassa au cours de sa carrière scientifique le vaste domaine du nannoplancton, était aussi un naturaliste complet. Sa grande érudition, ses dons d'observation, sa connaissance des langues étrangères (il parlait couramment l'anglais et l'allemand, traduisait l'italien et l'espagnol, et possédait des notions de russe) le poussaient à s'intéresser à tout ce qui l'entourait et c'était un plaisir de l'entendre commenter, toujours avec beaucoup d'esprit, telle ou telle idée nouvelle, telle ou telle découverte récente.

En la personne de G. DEFLANDRE, la Micropaléontologie perd l'un de ses plus éminents représentants. Son nom restera toujours attaché à cette discipline et son œuvre est le témoin d'une vie toute entière consacrée à la Recherche et à la Science.

Source MNHN, Paris

Source: MNHN, Paris

THE ASSOCIATIONS OF ALGAE WITH ARTHROPODS - II *

U. GERSON **

6. DELETERIOUS EFFECTS OF ALGAE ON ARTHROPODS

6.1 PHYSICAL INTERFERENCE

Several cases of algal growth on arthropods were noted above. Some appear to be fortuitous, others serve to camouflage the hosts, and in additional ones, to be discussed below, the algae parasitize the arthropods. The overgrowing plants may also adversely affect the host through physical interference. A pertinent report (GLYNN 1970) concerns algae growing on the marine isopod *Dynamenella perforata*, causing it indirect harm by interfering with crawling, swimming, feeding and other functions. BARNES and TOPINKA (1969) wrote that *Fucus* initially receives some protection from the barnacles on which it grows, but later the plants kill the animals by interfering with their feeding activity.

Indirect physical interference through decreasing transparency brought about by increasing phytoplankton production in lakes and rivers was postulated by FREY (1969) to affect populations of chydorid cladocerans. These animals utilize rooted aquatic plants as their main substrate, and the greater and deeper the area inhabited by the plants, the more varied the cladoceran populations. In low-productivity water bodies the plants extend to deeper zones, due to the greater transparency of the water. But with increased phytoplankton production transparency decreases, the extent of rooted aquatic plants becomes restricted, and consequently the number of cladoceran species declines.

6.2 OXYGEN DEPLETION AND OVERPRODUCTION

The depletion of oxygen in ponds by algae, or its overabundant production there, are specific mechanisms whereby arthropod populations may be affected

* Part I : *Rev. Algol.*, N.S., 1973 (1974), XI, 1-2 : 18-41.

** The Hebrew University, Faculty of Agriculture, Rehovot, Israël.

Rev. Algol., N. S., 1976, XI, 3-4 : 213-247.

Source MNHN, Paris

(EHRLICH 1966). *Chara fragilis* was lethal to some mosquitoes apparently due to excessive oxygen production (DARBY 1962). MARSHALL (1966) stated that *Daphnia* suffered prenatal mortality when held in a *Chlamydomonas* culture kept in the dark, possibly due to depletion of dissolved oxygen by the algae. Water trapped by large brown seaweeds (such as *Fucus* and *Ascophyllum*) at low tide becomes deficient in oxygen during the night or on cloudy days (WIESER and KANWISHER 1959). The lack of oxygen may paralyze or kill the arthropods which usually inhabit these brown algae. Efforts to reduce the amplitude of the diurnal oxygen curve in stabilization ponds so as to maintain *Daphnia* populations which help in water clarification, were detailed by EHRLICH (1966).

6. 3 INHIBITORY SUBSTANCES

SAUNDERS (1957) stated that there is some evidence for antagonistic activity of algal populations towards microcrustaceans, often enhanced by release of a substance from ingested cells within the animals. A tannin which immobilized the *Sargassum* epifauna was discovered by SIEBURTH and CONOVER (1965), the branch tips of the seaweed being observed to be virtually free of the usual epibiota. Appropriate chemical tests suggested the causal factor to be a tannin, which adversely affected copepods at dilutions up to 1 : 125, but not at higher ones (SIEBURTH and CONOVER 1965). Some other instances of this phenomenon were presented in reviews by LUCAS (1961) and SIEBURTH (1968). The term «ectocrines» was coined by LUCAS (1947) to denote biologically active excretory products of aquatic organisms that may have effects in marine ecology. A pertinent example was presented by SIEBURTH (1968). The brown alga *Ralfsia verrucosa* secretes some polyphenols which kill barnacle nauplii, thereby preventing their settlement in pools where the alga abounds.

6. 4 WATER BLOOMS AND TOXINS

The best known cases of toxin production by algae are those associated with «water blooms». The causes and development of these phenomena were discussed by LUND (1965), ROUND (1965), STRICKLAND (1965) and many others. These great outbursts of algal growth are often associated with widespread poisoning of fishes, birds, crustaceans and even terrestrial animals, which may suffer after drinking the waters (ROUND 1965). The pertinent literature was recently summarized by SCHWIMMER and SCHWIMMER (1968) (but see also VALKANOV 1964). Copepods, cladocerans, amphipods and decapods were among the affected crustaceans.

RYTHER (1954) believed that in rapidly multiplying algal populations some inhibitory substance («chlorellin») accumulates, which seems to exclude the grazers (the basis for this postulate, HARDY's exclusion theory, was discussed in a former paragraph). Later writers (RIGLER 1961; TAUB and DOLLAR

Source MNHN, Paris

1968, and others) criticized RYTHER and did not accept his chlorellin theory. TAUB and DOLLAR (1968), for instance, explained *Daphnia* inhibition at high algal concentrations by nutrient deficiencies rather than by toxic substances. A case where an alga is poisonous to arthropods only in special circumstances was described by STANGENBERG (1968). The plant was *Microcystis aeruginosa*, which contains a toxic substance. When *Daphnia* and *Eucypris* were kept on normal cultures, no mortality occured. But the toxin may be discharged from the algal cells by refrigerating and defrosting them. Considerable copepod mortality took place when such refrigerated-and-defrosted cells were placed in the cultures.

6. 5 THE BIOLOGICAL CONTROL OF MOSQUITOES BY ALGAE

Several authors have remarked on the effect of Characeae and other algae on mosquito larvae. FRITSCH (1956, p. 447) noted the frequent avoidance of waters harboring these algae by the larvae, though there was no clear evidence for the production of any larvicidal substances by the Characeae. REMUSAT (1962) claimed to have experimental proof that the larvae disappear from Characeae-containing waters because of the algae. It is only one step from such observations to utilizing them, i. e., manipulating the algae in order to control insect pests biologically. A review of such projects was presented by FRANZ (1961), who noted that most of these efforts were against mosquito larvae. The best results were reported by GERHARDT (1953, 1955). This author noticed that rice fields free from mosquito larvae supported rich blue-green algae, whereas the pests abounded in fields with lesser algal growths. GERHARDT (*l. c.*) wrote on the algae employed, on their culture and on successful introduction experiments. The green alga *Oedogonium princeps* is another promising agent for the control of anopheline larvae (GHOSH and HATI 1964). Other species may also prove useful in this respect, and on the whole it seems that the utilization of algae against insect (and other) pests which live in aquatic environements has been rather neglected.

6. 6 PARASITISM

Several algae are parasitic on arthropods, although it may sometimes be difficult to distinguish this association from the mere utilization of the animals as substrates (discussed in section 5. 2). FRITSCH (1956) cites CHATTON's work on endoparasitic algae, including the genera *Paradinium* and *Blastodinium*. Members of the latter genus castrate their copepod hosts (SEWELL 1951) and sex reversal in an attacked animal was reported by CATTLEY (1948). Many Euglenoidina were recently described as parasites of fresh-water copepods (MICHAJLOW 1966, 1968, etc.). The parasites attack the eggs and intestines of the hosts, often causing their death. In some cases the parasites begin their development in the nauplial eye and then spread to other parts of the body (MICHAJLOW 1966).

Source MNHN, Paris

6.7 ENTANGLEMENT

This mechanism was reported in regard to fishes, not arthropods, but it is pertinent to note it here. The water net, *Hydrodictyon reticulatum*, is a colonial alga whose cells become 4-5 mm long, forming a network with a mesh size of 6-8 mm in older plants. The colony forms a sac measuring up to 50 mm in diameter and 200 mm in length (LEWIS 1961). Many small fishes become entangled in the net, and, if unable to free themselves, they eventually die there. LEWIS (*l. c.*) thought that the alga may indirectly derive nutrients from the decaying fish, exerting a significant effect on small fish and fingerling populations. It is quite likely that some of the larger aquatic arthropods may similarly become entangled.

6.8 INDIRECT EFFECT OF HYDROLYZED SEAWEED

Some reports have been published in recent years concerning the indirect, adverse effects of algae, as hydrolyzed seaweed, on arthropods pests of agricultural crops. Some of the claims in these reports may have commercial undertones, but it seems worthwhile to note them in the present context. STEPHENSON (1966) stated that liquified seaweed, marketed as «Maxicrop» in the United Kingdom, may confer on broad beans, sugar beets and potatoes some resistance to infestation by aphids. The resistance was considered to be behavioral rather than nutritional, as the aphids (some of which are important plant virus vectors) were wandering restlessly on the plants. Maxicrop was also reported to protect orchard trees against infestation of red spider mites (Tetranychidae), almost like commercial pesticide treatments. The seaweed product appeared to have the additional advantage of continuously building up its effect, so that after 2-3 years the degree of control achieved was as good or better than that obtained by conventional acaricides. These effects were thought to be due to the enhanced effect of predators, which were unaffected by Maxicrop (STEPHENSON, *l. c.*).

The mecanisms protecting the Maxicrop-treated plants against these pests are not clear, but it is beleaved that the effect is mediated through the plants, and that it is not insecticidal (STEPHENSON 1966). Growth-regulating properties were also claimed for Maxicrop, and these may be involved in protecting the plants (BOOTH 1969).

A case of historical interest, concerning an attempt to protect potato plants from «potato bugs» with the help of algae, was related by SCHWIMMER and SCHWIMMER (1968). «Green lake scum» was applied to the potatoes, apparently to control the bugs. As a result both potato plants and bugs died.

7. ALGA-ARTHROPOD COMMUNITIES

7.1 COMMUNITIES ON SEAWEED AND ON FRESHWATER ALGAE

Certain arthropods have been associated with algae for prolonged periods, du-

Source MNHN, Paris

ring which they formed some specific communities. One such community is attached to *Sargassum* seaweed in the Sargasso Sea. This plant, originally coming from the coasts of the Caribbean and covering large areas in the Sargasso Sea, affords the base for a nomadic fauna of littoral origin, presumably stemming from the home of the seaweed (ALLEE and SCHMIDT 1951). There are only 16 animal species directly attached to this *Sargassum*. The animals had to undergo several adaptations in order to survive on this pseudobenthos, adaptations which include specialized attachment behavior, nest building and protective coloration. There are some arthropods among them, such as the crab *Planes minutus* and the shrimps *Leander tenuicornis* and *Latreutes ensiferus* (ALLEE and SCHMIDT 1951). A note of historic interest may be inserted here again. As Columbus was crossing the Atlantic in 1492, his crew observed seaweed floating by, with a crab attached to it. This sight suggested the proximity of land to the sailors, but actually they were only about midway across the ocean, sailing through the Sargasso Sea (BERRILL 1966).

ANDREWS (1945) recognized several faciations of algae and animals inhabiting kelp beds in the sea near the coast of California. Arthropods are involved in two of these faciations, one of which consists of *Macrocystis* and the decapod *Pugettia*, and appears to be seasonal. *Nereocystis* and the amphipod *Amphithoe* make up the other faciation which is permanent throughout the year. Assemblages of algae and ostracods were distinguished by WHATLEY and WALL (1969) in the southern Irish Sea. The laminarian assemblage was exclusively found on the holdfasts of *Laminaria digitata* and *L. hyperborea*, and its dominant ostracod was *Loxoconcha rhomboidea*. The littoral assemblage was dominated by *Cythere lutea* and *Heterocythereis albomaculata*, and occured on *Cladophora*, *Enteromorpha* and *Corallina*, but never on *Laminaria*. A *Fucus serratus* community, which includes many alga-feeding arthropods, were postulated to exist near the Swedish coast by HAGERMAN (1966). This author also noted that the alga's surface has a pronounced effect on the associated fauna, filamentous, scrub-like algae having richer faunae than leaf-like ones. Similar observations were recorded by JANSSON (1967), WHATLEY and WALL (1969) and others.

7.2 COMMUNITIES LIVING IN SEASHORE WRACK

BACKLUND (1945) conducted an extensive study of the faunae occuring in seashore wrack on Scandinavian shores, listing many arthropods. Later literature on this subject was reviewed by STRENZKE (1963), in the introduction to his experimental study of arthropod succession in seaweeds. This investigator placed fresh *Fucus* and *Enteromorpha* in open wire baskets near the seashore, and studied the arthropods occuring therein for a period of one year. Four distinct faunistic phases, correlated with sodium chloride content, were observed. In the initial, colonizing phase, during the first fortnight of sampling, the anthomyiid fly *Fucellia intermedia* and the mesostigmatic mite *Halolaelaps marinus* predominated. Little decay occured during this phase, nor were there any significant changes in the NaCl or water content. The second, «decayed matter» phase lasted from the third week to the beginning of the fourth month, and the do-

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minant arthropods were the spheroceriid flies *Limosina* spp. and the mite *Halolaelaps celticus*. NaCl content was still above 10%. During the third, «transitional» phase, the salt concentration fell to below 2%. This phase lasted up to 7-8 months from the experiment's beginning, and the more abundant animals were certain flies, such as the syrphid *Syritta* and the scatopsid *Scatopse*. The final phase was characterized by large numbers of the mosquito *Trichocera* and the collembolan *Hypogastrura*. Water content was believed to have an important modifying effect on this succession (which could be replicated during several years), but the dominant factor was considered to be sodium chloride content.

Additional work along the same lines has more recently been reported by MOELLER (1967), who found that Collembola, which tend to avoid high salinity conditions, have no effect on algal decomposition. YONGE (1949) considered the seaweeds to represent a «factor of the first importance» in the lives of many shore animals (arthropods included). Other observations on intertidal, kelp-utilizing insects were recorded by EVANS (1968), who also summed up many of the previous reports. One group which deserves special mention is the dipterous family Coelopidae, the seaweed or kept flies. These insects, occuring the year round in seashore wrack, spend their entire lives therein, as it provides them with a warm, humid environment and with the nourishing slime upon which the larvae feed (OLDROYD 1964).

The possible significance of seaweed banks as sites where the transition of animals from aquatic to terrestrial habitats could take place was discussed by LAWRENCE (1953). This author studies the cryptic soil arthropods of South African forests and noted that many of these animals had relatives able to live in the littoral. He believes that many archaic arthropods, in their attempts to live on land, initially colonized the intertidal zone where heaps of seawrack could afford them temporary shelter. Thus LAWRENCE (*l. c.*) thinks that seaweed beds, with their perpetually-moist interiors, might serve as terrestrial outposts for the colonizing arthropods eventually destined to live in forest soil. This theory was also discussed by KUEHNELT (1961), who did not however accept it.

7.3 COMPETITION FOR SETTLING SITES

Intertidal zones are sometimes the scene of competition for settling sites between arthropods (such as barnacles) and algae. A universal system of zonation for the area between tide-marks on rocky coasts was introduced by STEPHENSON and STEPHENSON (1949), who designated the middle part of the shore as the Balanoid zone. Various algae, among them fucoids, are known to interfere with the barnacles there. One such scene was described by RIGG and MILLER (1949) from the vicinity of Neah Bay, Washington, U.S.A. The animals were usually more successful in occupying the available sites, often completely crowding out the algae to the very borders of the barnacle colonies. In other areas algae gained additional anchorage by pushing their holdfasts among the animals. On the other hand, the latter were sometimes restricted to narrow belts above the algal beds, as the plants were apparently better adapted to the imme-

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diatly-adjacent vertical ranges (RIGG and MILLER 1949).

Germlings of *Fucus vesiculosus* attach onto barnacles and clams better than onto rocks, but their holdfasts are also easier to detach from the former surface. *Fucus* subsequently kills the barnacle on which it grows, and the empty shell with its algal growth is devoured by grazing limpets. These interactions were shown by BARNES and TOPINKA (1969) to affect the competition for space between barnacles and algae.

In exposed areas *Fucus* is less abundant than barnacles, as the alga often detached by wave action before attaining a size sufficient to kill the animals. With decreasing exposure the algae succeed in developing bigger plants, subsequently killing the barnacles (which are then removed by limpets). As a result the sheltered areas become available for further colonization by the algae, which grow on other substrates and deny access to invading barnacles. Additional observations on this subject were reported by MACFARLANE (1952) and GLYNE (1965) published an extensive study on algal-barnacle relationships and communities. Competition between algae and other arthropods - simuliid larvae - for space on rocks was reported by FEE (1967).

7.4 COMMUNITIES AFFECTED BY TECHNOLOGICAL CHANGES

Modern technology is bringing about many changes in algal distribution and abundance (and presumably in their associated arthropod fauna), and some representative cases will be noted. The hulls of present-day fuel tankers are generally free of animal fouling forms, apparently because of the ships' fast movement from tropical, warm seas to temperate waters. While this wide range of environemental conditions largely excludes animal foulers, it is highly favorable to certain algae, especially *Enteromorpha* (EVANS and CHRISTIE 1970). It may be predicted that this fouling alga, currently invading a new habitat, will eventually be found to have its own characteristic associated arthropod fauna on the tankers' hulls.

Lake Kariba in Central Africa is an artificial lake created in 1958 by damming the Zambezi River. Submerged trees serve as a newly-created substrate for animals (including arthropods) in this lake. The richest faunal standing crop was found where benthic algal populations were well developped (McLACHLAN 1970). In this case alga-arthropod communities are also evolving on a new and artificial substrate, but probably in the pattern they follow elsewhere.

Another example pertains to terrestrial epiphytic algae. ELTON (1966) noted that *Pleurococcus viridis* appears to be relatively resistant to industrial soot pollution in England, thus sometimes remaining the dominant epiphyte on tree trunks. Many arthropods depend on various epiphytic algae and lichens for food (BROADHEAD 1958; ELTON 1966). The relatively recent dominance of *Pleurococcus* will either exclude the animals which cannot utilize this alga, or make them change their diet.

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The effects of pollution and its often resulting eutrophication of waterways and lakes on algae and their grazers have been discussed by various authors; a useful summary was presented by BROOKS (1969).

7. 5 SOME GEOLOGICAL ASPECTS OF ALGA-ARTHROPOD ASSOCIATIONS

The frequent concomitant occurence of algae and arthropods in fossil beds attests to their manifold associations in the geological past. Algae have an affinity for silica, transforming it to the colloidal state, in which animals may be trapped. The resulting fossils are silicified arthropods which occur in calcareous lakebed nodules (PIERCE 1961).

The evolution of animals which feed on and burrow in algae was believed by GARRETT (1970) to have caused the decline of stromatolites. These are laminated structures built by dense mats of blue-green algae which selectively trap and bind sediment particles among their mucilaginous filaments. Stromatolites abounded in the Precambrian and declined from the Ordovician to become scarce in the Cenozoic. GARRETT (*l. c.*) suggests that this decline can probably be correlated with the evolution of new grazing and burrowing animals which began to appear during the Ordovician expansion. Further, the available geological data indicate that stromatolites and animals are usually mutually exclusive. To support his arguments, GARETT (*l. c.*) presents evidence that grazing and burrowing animals (gastropods, polychaetes, fishes and some arthropods such as shrimps and crabs) may prevent the formation of mats of blue-greens and destroy algal laminations.

Past periods of increasing phytoplankton production and lake eutrophication were deduced by FREY (1964) from changes in cladocerans occuring in Quaternary sediments. *Bosmina longirostris* is considered to be characteristic of more productive situations, and its replacing *B. coregoni* is thus considered evidence for increasing productivity in the water bodies whose sediments were studied. Although FREY later (1969) expressed some reservations about his interpretations, the method still appears to be rather suitable for similar reconstructions. Such an effort was made by SEBESTYEN (1969), who postulated past changes in the water level of Lake Balaton (Hungary) from the relative abundance of the alga *Pediastrum* and of cladoceran remains in lake sediments. As the alga is believed to be planktonic, its greater abundance (relative to Cladocera) indicates past periods during which a high water level persisted, with a corresponding dominance of planktonic life. The relative dominance of the Cladocera in the sediments, on the other hand, would suggest decreased water level periods during which benthic life was more abundant.

Past associations between arthropods and algae may have some bearing on the origins of oil, as discussed in section 2. 4. A different link was suggested by IOVINO and BRADLEY (1969). These authors found that the ooze in Mud Lake, Florida, consists exclusively of minute faecal pellets produced by larvae of the

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fly *Chironomus* whilst feeding on blue-green algae. The resultant pelletal ooze appears to be similar to lacustrine organic ooze believed to be the precursor of rich oil shale beds in North America. The analogy between the lacustrine copropel of Mud Lake and Eocene oil shale precursors is enhanced by the discovery of minute faecal pellets in thin sections of oil shale, and of immature chironomid remains in rich oil shale beds.

8. EFFECT OF PESTICIDES

8.1 EFFECT OF ALGICIDES ON ARTHROPODS

Many herbicides are currently being used to control algae in various habitats (MULLIGAN 1969). Copper sulfate, among the better known and more widely used compounds, is toxic to *Daphnia* and other aquatic arthropods (FISHER 1956; ROSE 1954). The toxicity of various aquatic herbicides to *Daphnia* was avaluated by CROSBY and TUCKER (1966), who concluded that several of these compounds may present a hazard to various major organisms in the food chain.

8.2 EFFECT OF INSECTICIDES ON ALGAE

Insecticides may reach the algae in their aquatic or terrestrial habitats both intentionally an unintentionally. In the former case, the chemicals are applied directly, to control arthropods grazing on algae (RAGHU and MACRAE 1967), crustacean parasites of commercial fish (LAHAV and SARIG 1967) or flies breeding in washed-up seaweeds (MARX 1967). Unintentionally, insecticides reach algae through runoff or drift from treated areas. The various responses of different algae to insecticides were discussed by several authors. MENZEL, ANDERSON and RANDTKE (1970) showed that three chlorinated-hydrocarbon pesticides vary greatly in their effects on four species of marine algae. The most sensitive of these, *Cyclotella nana*, was inhibited in its photosynthetic activity and in its growth by concentrations as low as 0.1 - 1.0 parts per billion. *Dunaliella tertiolecta*, on the other hand, was completely insensitive, and the other two species were intermediate in this respect. The possibility that the differential effect of pesticides may affect the succession and dominance of certain algae was also discussed by MENZEL *et al.* (1970). Additional insecticides were similarly tested by MOORE and DORWARD (1968), who also found that various algae were differently affected by these chemicals. Malathion, an important organophosphorous insecticide, was quickly metabolized by some algae, a finding which led to the conclusion that these plants may be important factors contributing to the disappearance of pesticides from natural communities. The use of algae as pesticide indicators was advocated by MOORE (1967), though CHOLNOKY-PFANNKUCHE (1969) warned against generalizations obtained from bioessay tests with these plants.

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Some algae which may be quite resistant to insecticides appear capable of biologically concentrating these compounds in their bodies (VANCE and DRUMMONS 1969). The crustacean suspension feeders, in their turn, also concentrate such substances from their algal food, and may thus ingest and accumulate high insecticide doses. Generally, the aquatic arthropods are far less insecticide-resistant than are the algae. The danger of such poisoning and its effect on the food chains in the oceans was noted by MARX (1967).

9. DISCUSSION

9.1 THE SCARCITY OF SYMBIOSIS

Apparently the only arthropods so far reported to have symbiotic or mutualistic associations with algae are damsel fly naiads (SELVARAJ and JOB 1965; WILLEY *et al.* 1970) and chironomid larvae (BROCK 1960). One thus becomes aware of what is perhaps the outstanding feature of the associations between algae and arthropods, namely, the extreme scarcity of symbiosis between these two groups of organisms. Both groups have many times evolved symbiotic relationships with representatives of other phyla. The insects (to mention the dominant arthropod class) have bacteria, yeasts and fungi as their plant symbionts (BUCHNER 1965). Various symbiotic alage have Protozoa, Porifera, Coelenterata, Ctenophora, Rotatoria, Platyhelminthes, Annelida, Mollusca, Echinodermata and Tunicata as their animal hosts (DROOP 1963; McLAUGHLIN and ZAHL 1966). No arthropod host for algae was listed by any of these authors, nor has a symbiotic alga been recorded as present within an arthropod host by BUCHNER (1965).

Though one is at a loss to explain the rareness of symbiotic relationships between algae and arthropods, several ideas come to mind. The foremost is that so few of these associations have been recorded simply because they have not yet been discovered. McLAUGHLIN and ZAHL (1966) noted that additional alga-bearing animals are constantly being reported. Further, as DROOP (1963) remarked, tropical animals, which have higher rates of metabolism than their temperate-zone counterparts, may have a greater need for the complementary services of symbiotic algae. It is just these tropical arthropods which are the less known, and it is among them that additional symbiotic relationships with algae may be found. The recent reported instances of arthropod-algal symbiosis (SELVARAJ and JOB 1965; WILLEY *et al.* 1970) lend support to the argument that many symbiotic associations remain undiscovered.

Another possibility is that algal symbiosis has, in fact, evolved in some arthropods, but as these became extinct, the relationship died out.

DROOP (1963) noted that, despite the occurence of algal symbiosis in animals representing many phyla, few algal types participate in these associations, the commonest being zoochlorellae of the genus *Chlorella*. This suggested to DROOP (*l. c.*) that few algae are sufficiently tolerant to their hosts to be able to

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live within them. The lack of enough algal candidates for symbiosis may thus contribute to their scarcity in arthropods. And even algae capable of such associations may require a change in host resistance through some weakness in order to become established. A recent case of human algal infection is pertinent in this respect. KLINTWORTH, FETTER and NIELSEN (1968) reported on a case of human cutaneous infection caused by *Prototheca wickerhamii*, an achloric alga which sometimes occurs saprophytically on animals and men. The patient, suffering from diabetes mellitus and breast cancer, was under heavy drug treatment. To explain the pathogenic occurence of *Prototheca*, KLINTWORTH *et al.* (*l. c.*) postulated that both the disease and the drugs altered and lowered body resistance, thus enabling the alga to become cutaneously established. It is of interest to note that *Prototheca* «appears to be no more than a colorless *Chlorella*» (FRITSCH 1956), the commonest symbiotic zoochlorella.

A different factor contributing to the scarcity of algal-arthropod symbiosis may be the production of inhibitory substances by the algae : see reviews by LUCAS (1961) and SIEBURTH (1968). It is noteworthy that some coral zooxanthellae produce terpenes which inhibit and exclude other animals (McLAUGHLIN and ZAHL 1966).

Whatever the validity of these speculations (and admitting that they do nothing to explain symbiosis between algae and other animals), the scarcity of algal-arthropod symbiosis remains an unexplained biological phenomenon.

9. 2 A PROPOSAL FOR ALGAL MANAGEMENT

This survey of algal-arthropod associations has shown that algae may be both beneficial and harmful . They are involved in sewage treatment and enrich the soil with nitrogen, they form the base of the great food chains in the oceans (and some fish ponds) and are utilized for many commercial purposes. On the other hand, algae cause «water blooms» that are sometimes toxic, and the «decay» of water bodies (FERGUSON 1968); they are weeds in kelp beds (CHENG 1969) and even pests of woody plant cuttings (COORTS and SORENSON 1968) and tea and coffee crops (FRITSCH 1956). For a detailed «algal ledger», presenting the credits and debits of algae, see PRESCOTT (1969).

The above presentation is intended to convey the idea that a greater effort should perhaps be made to manipulate algal populations. The harm algae do may be reduced or, conversely, their beneficial effects can be enhanced. The potential of algae as biological control factors has hardly been tapped, and the possibility of biologically suppressing algal pests is still only a suggestion (MULLIGAN 1969). Such manipulation obviously calls for an interdisciplinary attack on algal ecology (SIEBURTH 1968), for better management of algal resources or, to use a term currently in vogue, for algal management. (The term was recently introduced in a more restricted sense by MULLIGAN 1969). Evidently the preservation and manipulation of algal resources is to be but part of the preservation of all marine and freshwater resources, as advocated by various authors (i. e., MARX 1967). However, because of the dual potential of algae, their ability to be both

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beneficial and harmful, some special measures are needed, and hence this proposal for algal management.

ACKNOWLEDGMENTS

Dr. D. K. McE. KEVAN Chairman, Department of Entomology, MacDonald College of McGill University, critically reviewed the manuscript, added some references and permitted me to use unpublished personal observations. Dr. F.E.A. CUTTEN, also of MacDonald College, likewise made useful suggestions. Dr Ralph A. LEWIN, of Scripps Institution of Oceanography, read the first draft of the manuscript and offered some useful critical comments. Drs D. KAHAN and M. RAHAT, both of the Hebrew University of Jerusalem, made several helpful suggestions. I wish to express my gratitude to all of them.

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THE ASSOCIATIONS OF ALGAE WITH ARTHROPODS

ADDENDUM

U. GERSON

Many additional papers and books which discuss various aspects of the associations between algae and arthropods have become available since the preparation of this article. Only the more relevant ones will be noted, arranged under the same section headings and in the same order.

1. INTRODUCTION

A review on the associations between lichens and arthropods was prepared and published (GERSON 1973) whilst awaiting publication of the present paper.

2. 2 SEASONAL, DIURNAL AND STAGE-DEPENDENT FEEDING

DEONIER (1972) reviewed the algophagus habits of adult shore flies (family Ephydridae). These flies use their prestomal teeth to scrape algae off the substrates, leaving depressions in the algal mats.

JOSEPH (1974) reported on the effect of tidal rhythm on the feeding activity of *Hyale hawaiensis*. This intertidal amphipod feeds on the green alga *Enteromorpha compressa*, feeding being most intense at high tide, as the algal belt becomes covered by rising water. Ebb entails decreased feeding. This rhythmic phenomenon is believed (JOSEPH, *l. c.*) to be caused by the inhibitive effect of depleted oxygen caused by algal respiration.

2. 3 ALGA-ARTHROPOD FOOD CHAINS

The book «Marine Food Chains», edited by STEELS (1970), contains some relevant papers on marine arthropods. CUMMINS (1973), in his review on trophic relations of aquatic insects, notes various alga-feeding species.

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2. 5 PHYTOPLANKTON-ZOOPLANKTON INTERACTIONS

ESAIAS and CURL (1972) conducted grazing experiments with 3 species of bioluminescent dinoflagellates and 3 calanoids. Ingestion rates were lowest for the highly bioluminescent dinoflagellates. The authors attach considerable survival value to the dinoflagellates' flashes of light, postulating that these flashes serve to defend their emitters by startling and confusing copepod grazers. ESAIAS and CURL (*l. c.*) further believe that this bioluminescence, by causing selective feeding, could be a factor in the formation of red tides and permanent blooms of biolumenescent dinoflagellates.

2. 8 REARING ARTHROPODS ON ALGAE UNDER CONTROLLED CONDITIONS

Various laboratory studies have recently been published on the effects of diverse algal diets on aquatic arthropods (ARNOLD 1971; BATTAGLIA 1970; BETOUHIM-EL and KAHAN 1972; NASSOGNE 1970; SCHINDLER 1971, and others). The results of these studies support the opinion that increasing the number of algal species in culture media enhances the survival rate of more arthropods species. This is due to the considerable selectivity exercised by the arthropods (mainly copepods) in regard to the species of algae available, their size and concentration. SCHINDLER (1971) expressed the opinion that phytoplankton-zooplankton correlations, often used to show relationships, are deficient whithout a better understanding of feeding relationships between algae and their grazers.

2. 9 THE UNSUITABILITY OF SOME ALGAL DIETS FOR ARTHROPODS

The algae *Anacystis nidulans, Merismopedia* sp. and *Synechocytis* sp. showed some toxicity or inhibition toward *Daphnia pulex* when offered as food (ARNOLD 1971). *Calanus helgolandicus* releases most of its daily captured ration of the diatom *Biddulphia* as undigested foodstuff (CORNER, HEAD and KILVINGTON 1972). The reason is not known; explanations offered include difficulties in diatom cell assimilation or possible inhibitory substances present therein. Best growth rates of the harpacticoid copepod *Euterpina acutifrons* were obtained with algal cells of medium size (7-16 μm) (NASSOGNE 1970). Smaller (6-7 μm) or wider ($>$ 16 μm) algae gave lower rates or did not support adult survival; algal food size may therefore be a limiting factor for these arthropods. Somewhat similar observations were reported by WINTERBOURNE (1971) in regard to larvae of the caddisfly *Banksiola crotchi*. They feed on stripes which they scrape from filamentous algae. As these larvae cannot digest unbrocken algal cells, algae with broad and long cells constitute the food best utilized; stripes from such algae have the highest ratio of brocken to unbrocken cells. On the other hand, algae with small cuboidal cells, such as *Hyalotheca*, constitute inefficient diets (WINTERBOURNE 1971).

Source MNHN Paris

PORTER (1973) conducted experiments on differential grazing by crustacean zooplankton on a natural phytoplankton community in Fuller Pond, Connecticut, U.S.A.. From her results PORTER (1973) concluded that, by their response to grazing, algae can be divided into three major groupings that cut across taxonomic lines. One group contains large, rare or filamentous species which are either unavailable to the grazers or actively rejected. Algae in the second group are small and edible, while those in the third are encased in thick gelatinous sheaths. Such algae pass intact through the alimentary system of their grazers, coming out in viable condition. Consequently, algae in the first group remain unaffected by such grazers, those in the second decrease in numbers, and species in the third group increase (through fragmentation and competitor suppression).

Data on the protection afforded bioluminescent dinoflagellates against copepod grazers (ESAIAS and CURL 1972) were noted in the addendum to section 2. 5.

2. 12 ARTHROPODS AS PESTS OF ECONOMICALLY-IMPORTANT ALGAE

The periodical Nova Hedwigia has devoted its Heft 32 to «The biology of Giant Kelp Beds (*Macrocystis*) in California», edited by W. J. NORTH (1971). It contains several papers on kelp grazers, including arthropods.

The manipulation of arthropods for the biological control of some seaweed pests was suggested by MANN (1973). Sea urchins (*Strongylocentrotus* spp.) graze heavily on seaweed and kelp in many parts of the world. MANN (*l. c.*) postulated that recent sea urchin outbreaks were triggered by reductions in the populations of their predators. The lobster *Homarus americanus* is considered to be the key sea urchin predator in eastern Canada. Its numbers were seriously reduced through human activity, and MANN (1973) advocates the protection and augmentation of lobster populations for the purpose of sea urchin control.

3. 1 FEEDING ON ALGAE IN THE INTERTIDAL ZONE

The thysanuran *Petrobius brevistylis* lives in rock crevices along the beach, where it feeds on *Pleurococcus* (LARINK 1968). Grapsid crabs were reported by GRIFFIN (1971) to feed on red and green algae, which they scrape off the surface of rocks in Tasmania.

3. 2 FEEDING ON SOIL ALGAE

The collembolan *Hypogastrura viatica* feeds exclusively on unicellular algae, which are very abundant in the upper soil layers where it lives. Subsoil algae become available to *Hypogastrura* through the burrowing activities of other insects, such as beetles and fly maggots (KRAAN and VREUGDENHIL 1973). RAPOPORT and TAGLIABUE (1964) applied dried and ground littoral algae as soil

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fertilizer, and noted first a decrease and subsequently an increase in soil arthropod populations. The authors believe this increase to be due to the enhanced fecundity of algae-feeding arthropods as well as to attraction of outside animals to the new and abundant food source.

WHEELER, HAPP, ARAUJO and PASTEELS (1972) isolated a pygidial secretion from the staphylinid beetle *Bledius*. One or more components of this secretion may regulate the growth of algae which flourish within the burrows of *Bledius* and upon which the beetles feed.

4. 1 CASE AND TUBE CONSTRUCTION

The importance of algae in the behavioral ecology of the shrimp *Alpheus clypeatus* was pointed out by BOWERS (1971). He found that the algal tubes which the animals construct play a significant role in their pair formation and species spacing within the habitat. Presence of algae curtailed the shrimps' aggressive behaviour whilst enhancing the survival rate of their heterosexual pairs. BOWERS (*l. c.*) concluded that algal tubes provide the basis for a territorial social system which 1) allows the shrimps a higher population density, 2) increases the exploitable surface of their habitat.

4. 3 SUBSTRATE AND SHELTER

WALLNER (1935) published an hitherto unnoticed paper on interactions between lime-depositing algae and chironomid flies. He concluded that the presence of such algae enables the flies to initiate their colonization of fast-flowing streams. BROCK (1970), in his review on High Temperature Systems, included several instances of arthropods which live in algal mats in relatively hot (ca. 40° C) waters. A new method for mass- rearing the dipteran *Chironomus riparius* was described by CREDLAND (1973), a method based on the availability of more larval settling sites on filamentous algae maintained in plastic tanks. BARNARD (1972), who collected amphipods in New Zealand, noted that *Caulerpa* beds were especially rich in these animals, whereas *Hormosira* was generally a poor refuge for amphipods.

Tropical floating marine algae were observed by TEETER (1973) to accommodate some ostracods. These findings suggest an explanation for the transoceanic dispersal of ostracods within tropical latitudes (TEETER, *l. c.*). Another mode of ostracod dispersal may be while attached to sections of algae floating in water taken into bilge tanks of oil tankers and bulk-carrying ships during ballasting while sailing across the Panama Canal (TEETER 1973).

5. 1 NUTRIENT REGENERATION

CORNER and DAVIES (1971) reviewed the role of plankton in the nitrogen and phosphorus cycles taking place in the sea, and included diverse algal-arthro-

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pod grazing relationships. BROCK (1970) noted that colonization of algal mats by ephydrid flies promotes mat mineralization, usually a rather slow process.

The shells of diatoms ingested by some copepods are voided while encased within a membrane which protects the enclosed diatoms from dissolution during their descent to ocean floor (SCHRADER 1971). These pellets sink many times faster than a single shell, thus rapidly transporting silica from surface water to deeper layers. The process may deplete the upper waters of silica (and other nutrients), while delivering an abundance of this mineral to the ocean floor. Such excess extraction drives surface water toward undersaturation, until solution rates on the ocean floor provide the necessary balance for equilibrium of silica reservoirs in the ocean (SCHRADER, *l. c.*).

5.3 MUTUALISM AND SYMBIOSIS

WILLEY (1972) described the cycle of the euglenoid *Colacium* which inhabits damsel-fly hindguts in an interdunal pond in Indiana, U.S.A. During fall *Colacium* flagellates enter the insects' rectum by swimming directly through the anus. The alga later secretes a gelatinous material by which it is held to the rectal walls. Large *Colacium* colonies are then formed, which occur in the rectum of the damsel-fly naiads as green plugs, easily seen through the hosts' abdominal walls. In spring some *Colacium* cells leave the host organ with fecal pellets, but most are ejected with the rectal cuticle as it is cast off during molt. Damsel-fly naiads are not reinfected prior to emerging as adults.

Other observations on *Colacium* were published by ROSOWSKI and KUGRENS (1973). These authors were mainly concerned with the formation and morphology of attachment material, an important character in the taxonomy of *Colacium*. They suggested that structure and formation of attachment material produced by copepod-colonizing *Colacium* may be affected by concentrations of trace elements in the arthropods' exoskeleton.

Some additional observations on the *Nostoc-Cricotopus* mutualism were published by TODD (1971), while recording new algae from Colorado, U.S.A..

5.4 DISPERSAL

The mud dauber wasp, *Sceliphron caementarium*, and the cabbage butterfly, *Pieris protodice*, were shown by SIDES (1970, 1971) to transport viable algae (and protozoa). The algal cultures obtained were similar to those found by former investigators. It was concluded (SIDES, *l. c.*) that *Sceliphron* may be a relatively important carrier of algae and protozoa, but that the cabbage butterfly is only a minor vector. SOLON and STEWART (1972) reported that carnivorous insects such as dragonflies (Odonata), preying on other insects which live near water, may also transport viable algal cells, this dispersal being merely accidental or incidental.

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ANDERSON, LEIDHAL and BRASHIER (1971) reported on the presence of viable algae in the anterior and posterior gut parts of the chironomid fly *Tendipes plumosa*. Presence of algae in the latter part suggests that they may also be dispersed by this midge.

Dissemination of viable algal propagules into the tissues of another plant by chironomid larvae was postulated by BERG (1950). That author found small larvae of *Cricotopus flavipes* excavating longitudinal mines in stems of the macrophyte *Potamogeton*. Viable algae, identified as *Nostoc*, *Anabaena* and others, were also found in the excavations. BERG (*l. c.*) thought it possible that the larvae had introduced the original algal propagules into the mines, where the algae were growing as rapidly as they were being eaten by the larvae.

6.4 WATER BLOOMS AND TOXINS

O' BRIEN and DE NOYELLES (1972) reported on a pH-related mortality factor which affected cladocerans in nutrient-enriched ponds maintaining very high levels of primary production. Ryther's 1954 results were reinterpreted by O' BRIEN and DE NOYELLES (1972) as having been caused, in part, by a similar elevated pH mortality factor.

6.5 THE BIOLOGICAL CONTROL OF MOSQUITOES BY ALGAE

A significant contribution in this area was made by AMONKAR (1969) in his Ph. D. thesis (later summarized by REEVES 1970). Amonkar isolated several algal cultures from southern California freshwater bodies in which natural control of mosquito larvae was apparently taking place. Cultures of *Cladophora glomerata* (denoted as culture AL-001), *Schizothrix friesii* (AL-003), *Chara fragilis* (AL-004), *Chlorella ellipsoidea* (AL-005) and *Chara elegans* (AL-010, AL-011, AL-012) exhibited marked larvicidal properties. The effects of these algae were assayed by their sterile, spent growth media whose usually alkaline reaction did not, by itself, affect the larvae. This indicates that the larvicidal activity is due to toxic substances which the algae release into the surrounding water (or culture medium).

The spent algal media (and purified concentrations prepared thereof) delayed mosquito egg hatching, reduced larval weights and, most significantly, proved to be highly larvicidal. AL-001 and AL-003 were the more toxic. Histopathological studies on mosquito larvae treated with the chromatographically-purified AL 001 toxic fraction revealed destructive effects on the epithelial lining of the alimentary canal. This damage disrupted normal food passage through the alimentary canal, causing leakage of gut contents into the haemocoel.

The toxin secreted by AL-001 is a heat-stable, non-dialyzable compound, whose ultraviolet and infra-red spectroscopic patterns suggest that it is an unsaturated organic substance with a nitrile group as well as terminal methylenes.

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The active fraction from AL-003 appears to be a similar although different compound. The toxic secretions of AL-004, 010, 011 and 012 are identical, having sulfoxide and terminal methylene groups.

These natural toxins appear to be quite specific mosquito larvicides, as no adverse effects on other organisms - including water insects - could be detected in the original freshwater bodies. The findings of AMONKAR (1969) are therefore of wide practical importance, a point which he emphasized. He also reviewed most of the literature on algae which inhibit or kill mosquito larvae. Deleterious aspects of the use of algae to control mosquitoes were discussed by YEO (1972), who suggested that such algae - especially *Chara* and *Cladophora* may cause some aquatic nuisance problems.

The findings about a toxic substance secreted by *Cladophora glomerata* bring to mind results reported by ISHAC and BISHAI (1968) regarding the effect of this alga on *Biomphalaria boissyi*, the snail host of *Schistosoma mansoni*, the causal agent of bilharziasis. Growth of *C. glomerata* on the shells of the snails reduced the latters' fecundity as well as egg fertility and hatchability. ISHAC and BISHAI (*l. c.*) attributed these effects to presence of acrylic acid CH^2=CH–COOH) in *Cladophora*. The toxic compound isolated by AMONKAR (1969) from *C. glomerata* could thus have been a polymerization product of acrylic acid, whose carboxyl group was replaced by a cyanide to form a nitrile.

6.8 INDIRECT EFFECTS OF HYDROLYZED SEAWEED

HAMSTEAD (1970) conducted two experiments with the hydrolyzed seaweed product Sea-Born(R), intended to control the two-spotted spider mite, *Tetranychus urticae*. In the first experiment a substancial decrease took place in the pest populations following applications of the seaweed hydrolysate and releases of a predaceous mite, as compared to predator releases combined with water sprays. In the second, more detailed experiment, no discernible decline in pest populations followed applications of Sea-Born(R) by itself.

7.1 COMMUNITIES ON SEAWEED AND ON FRESHWATER ALGAE

Competition within an animal community living on algal belts in the Baltic Sea off the Swedish coast was studied by JANSSON (1969). She found that early in july the belts are colonized by juveniles of the isopods *Idotea baltica* and *I. chelipes* which feed on the algae and on sessile diatoms living thereon. Their feeding causes various competition patterns to occur among the isopods as well as among the rotifers and ciliates which live in the same community.

WIEGERT and MITCHELL (1973) studied the effect of algal mat stability on adult brine fly (*Paracoenia turbida*) parasitization by the water mite *Partnuniella thermalis*. The fly lives in and on mucilaginous mats formed by blue-green algae and bacteria in hot springs at Yellowstone National Park. *Paracoenia* has a

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short life cycle (14 days at 35° C), and its voracious larvae can rapidly destroy suitable mats. The mite, on the other hand, has a slower life cycle, consequently parasitizing its host-flies only in relatively stable mats. The mite-fly intersect (i. e., percent of flies parasitized and size of mite load on these flies) may therefore be used as a sensitive measure of mat stability.

7. 3 COMPETITION FOR SETTLING SITES

LIPKIN and SAFRIEL (1971), in their studies on the zonation of Mediterranean rocky shores at Mikhmoret, Israel, found that populations of the barnacle *Chthamalus stellatus* may be suppressed by algae in the mid-midlittoral intertidal zone. Individual barnacles may, however, survive under the algal cover.

7. 4 COMMUNITIES AFFECTED BY TECHNOLOGICAL CHANGES

Algal growth on flooded trees in the man-made Volta Lake (Ghana) supports a great abundance of the borrowing mayfly *Povilla adusta* (PETR 1971). The insects are heavily exploited by commercial fish. A man-made alga-insect-fish food chain, of considerable importance in the convertion of algae into animal protein, has thus evolved as a result of technological changes.

The pollution-associated disruption of invertebrate communities which live in kelp forest holdfasts in the North Sea was described by JONES (1973). He noted that many species (including numerous arthropods) have disappeared from these communities. Mechanical harvesting (raking) of Irish moss (*Chondrus crispus*) near Prince Edward Island damages many «moss»-associated lobsters, reducing their landed value by about 7% (SCARRATT 1973).

The reduction of herbivorous crustaceans by insecticide treatments of freshwater ponds was observed by HURLBERT, MULLA and WILLSON (1972) to be followed by phytoplankton increases to bloom dimensions.

7. 5 SOME GEOLOGICAL ASPECTS OF ALGA-ARTHROPOD ASSOCIATIONS.

Some copepods produce diatom-containing fecal pellets which are enclosed within a membrane (SCHRADER 1971). These pellets form deep-sea diatom sediments occuring down to 4000 m off the coast of Portugal. The diatoms would not have sunk by themselves, without being enclosed by the membrane, as they would have been completely dissolved before reaching such depths. This illustrates the role of copepod-produced fecal pellets in the sedimentation of pelagic diatoms.

Source MNHN, Paris

8. 2 EFFECT OF INSECTICIDES ON ALGAE

Insecticide concentration in algae, the differential reaction of diverse algal species to insecticides, and effect of the resultant variable mortality (or inhibition) on aquatic ecosystems and food chains were discussed in some recent papers.

COX (1970) found that the level of DDT and some of its metabolites was tripled in phytoplankton samples collected off the Californian coast from 1955 to 1969. Several freshwater algae, such as *Anacystis nidulans, Scenedesmus obliquus* and *Euglena gracilis*, concentrated DDT 850, 630 and 100 fold, respectively, from their media (GREGORY, REED and PRIESTER 1969). The organophosphorus insecticide parathion was concentrated by these algae about 50-70 times. The ability of algae to retain and concentrate insecticides may have implications for control of pests which live in and feed on these plants. BURTON (1973) discussed such possibilities upon finding huge numbers of black fly (*Simulium*) larvae feeding exclusively on *Oedegonium* filaments in Ghana.

EGLOFF and PARTRIDGE (1972) showed that *Chlamydomonas reinhardtii* was not affected by concentrations of 100-1000 ppb of DDT. These authors speculated that such relatively-resistant species might displace less tolerant ones in polluted situations and thereby reduce or alter species composition in freshwater bodies exposed to insecticides.

This idea was experimentally explored by MOSSER, FISHER and WURSTER (1972). DDT or polychlorinated biphenyls were added to mixed cultures of the insecticide-susceptible diatom *Thalassiosira pseudonana* and the resistant green alga *Dunaliella tertiolecta*. In mixed control cultures the diatom grew faster and became dominant. But the dominance of *Thalassiosira* diminished on introducing the chemicals, even at concentrations that had no apparent effect when added to pure algal cultures. MOSSER et al. (*l. c.*) concluded that such stable pollulants «could profoundly affect the health, distribution and abundance of many animal populations higher in the food web». A more moderate opinion as to the effect of DDT on oceanic life was expressed by JUKES (1974).

The interactions of pesticides and algae were discussed within the context of pesticide-microorganism reviews by PFISTER (1972) and by WARE and ROAN (1970).

Several more technical papers on this subject were recently published in the Bulletin of Environmental Contamination and Toxicology but they are outside the scope of the present review.

9. 1 THE SCARCITY OF SYMBIOSIS

Doubts about the validity of the reported wide systematic range of invertebrate hosts for algae were expressed by TAYLOR (1973). He argued that most animals which participate in symbiotic associations with algae are characterized by a relatively low level of intercellular co-ordination. The introduction of alien

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cells into tissues of such invertebrates would do little to disrupt the animals' underlying organization. Further, these animals have low or non-existent immunological barriers. Cohabitation with algal cells thus causes little cellular difficulties for the host. TAYLOR (*l. c.*) also pointed out that the majority of symbiotic hosts are carnivores, hence less likely to be capable of digesting their associated algae. The establishment of symbiosis with herbivores probably depends upon algal resistance to digestion as well as increased host susceptibility.

These remarks go a long way towards explaining the scarcity of symbiosis between arthropods and algae. They cannot however apply to associations involving bacteria, yeasts and fungi, as these organisms often occur as symbiotes of insects, animals with highly developed cellular co-ordination. One thus feels that algae are rather different from other microorganisms in their relative suitability for symbiosis, as already suggested by DROOP (in main reference list).

TAYLOR (1973), as noted, pointed out that most invertebrates which host algae are carnivorous. It is therefore of interest that the only arthropods hitherto reported to have algal symbiotes are damsel flies, which are predaceous insects. It is of further interest that the symbiotic algae studied by WILLEY (1972) enter their host via its rectum, and those reported by SELVARAJ and JOB (in main reference list) live in the caudal lamellae of their host, near the main tracheal branches. The symbiotic algae are not very likely to be much affected by their hosts' digestive system in either case.

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VAUCHERIA ON «CORAL» (LITHOTHAMNION) SAND

J.P. CULLINANE*

SUMMARY. – Species of the genus *Vaucheria* usually grow in or on very damp soil or mud or even submerged in either fresh or salt water. In the Connemara district of County Galway in the west of Ireland, *Vaucheria* was found growing on coral sand (*Lithothamnion calcareum).* This very coarse and brittle substrate contrasts completely with the more usual type of habitat. Four species have been found, namely : *Vaucheria geminata* (Vauch.) de Candolle, *V. sessilis* (Vauch.) de Candolle, *V. de Baryana* Woronin and *V. pachyderma* Walz. The latter two species have not been previously recorded from Ireland.

RÉSUMÉ. – Les espèces du genre *Vaucheria* poussent habituellement sur ou dans des sols humides, boueux ou même recouverts par des eaux douces ou salées. Dans le district de Connemara dans le comté de Galway, à l'ouest de l'Irlande, des *Vaucheria* ont été récoltées sur des sables à *Lithothamnion calcareum*. Ce type de substrat diffère totalement de l'habitat type usuel de cette algue. Quatre espèces ont été récoltées : *Vaucheria geminata* (Vauch.) de Candolle, *V. sessilis* (Vauch.) de Candolle, *V. de Baryana* Woronin et *V. pachyderma* Walz. Les deux dernières espèces sont signalées pour la première fois en Irlande.

I. INTRODUCTION

The *Vaucheria* was first noticed on the coral sand on march 3, 1969 at Ardmore on the Carna side of Killkieran bay and later on june 23 at Carraroe. In march 1970, it was found on a third coral strand at Streamstown bay, north of Clifden. In april 1970 it was found on another coral strand on the western side of Gorumna island. The habitat was unique. At Ardmore, Carraroe and Mannin bay drainage from the fields above creates a channel in the coral sand and the Vaucheria grows in this. Heavy rains fill the channel so that the *Vaucheria* is then submerged in fresh water. Either the fresh water drainage or the high tide can cause the sand in the channel to collapse and cover the *Vaucheria* but within a few days it grows up through the sand and forms a new mat on the surface. At both Streamstown bay and Gorumna island, the habitat was essentially the same but the *Vaucheria* grew in very small amounts on large clean coral directly underneath a trickle of water which seeped from a rock.

The four species recorded from this type of habitat are not included in the Check-lists of British Marine Algae (PARKE and DIXON 1968). However, where they were growing on the coral sand they were subjected to submersion by the high tide. Examination of specimens following or during a high tide showed that

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Rev. Algol., N. S., 1976, XI, 3-4 : 249-259.

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the *Vaucheria* was plasmolysed and it then usually became extremely fertile within a few days. Material of *V. geminata* collected from coral strands at both Ardmore and Carraroe was compared with material of the same species from the Cambridge Culture Collection. The latter was plasmolysed by 40% saltwater whereas the coral strand material was only slightly plasmolysed 50% saltwater. Aplanospores and akinetes from the coral strand material germinated in fresh water, half seawater and in full seawater but survived for far longer period in half seawater. Although growing in very saline conditions the *Vaucheria* on the coral does depend on the fresh water drainage as it does not grow during the dry summer months when even the channels are not present. The *Vaucheria* reappears early in october and remains throughout the winter months. However, its occurence depends more on rainfall than on the actual seasons since, following about four days of very heavy rain during june 1969 and july 1970, the *Vaucheria* was found but it soon disappeared when the channel again dried out.

None of the specimens growing on the coral were impregnated with calcium as were samples collected by CHRISTENSEN (1969) from the rapids of a brook and described by him as «small cushion-like masses so heavily encrusted with lime that they felt hard and stone-like when collected».

II. DESCRIPTION OF THE SPECIES

a. *VAUCHERIA DE BARYANA* WORONIN. (fig. 1-15).

WORONIN (1880) in naming this species after DE BARY states that he found it in small fast running rivers and in the well of a spring. VAUCHER (1803) states that it grows in dull green masses in ditches with stagnant water. CHRISTENSEN (1969) collected this species on soil near running water and actually in water and in places flooded by water now and then. These and other records of this species, GOETZ (1897), DANGEARD (1939), RIETH (1965) contrasts with the maritime conditions on the hard brittle coral sand.

The first specimen collected at Ardmore coral strand formed a thick mat about six inches in diameter and dark green in colour with pale edges. The mat was divided into four parts and these were kept in separate crude cultures and each became fertile within four days. The reproductive organs and filament widths matched those of *V. de Baryana* as described and illustrated by WORONIN (1880), VENKATARAMAN (1961), RIETH (1965) and CHRISTENSEN (1969).The oogonia were on stalks 80-100 μm long and were slightly oval in shape and measured approximately 40 by 60 μm. The mature oogonium had an inconspicuous terminal beak (fig. 1-3). The oospores frequently germinate while still attached (fig. 4). The antheridium was situated between the two oogonia and was on a long stalk. It had the characteristic flattened anvil shape, which along with the small filament width readily distinguishes this species from all others. The antheridium had two lateral openings, with three on rare occasions. On an

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average it measured 20 μm high by 35 μm wide.

Twenty-seven days after collection the plant died off but filaments reappeared after twelve days and were fertile within another twelve days. The reproductive organs were similar but the oogonia were on shorter stalks and in some cases were almost sessile so that they were at a lower level than the antheridium (fig. 5-7). This variation is also illustrated by VENKATARAMAN (1961, fig. 68) and by CHRISTENSEN (1969, fig. 6848a). By the time the culture was eight weeks old, the oogonia were almost all completely sessile with only one to each antheridium, a feature which was consistent in one sample described by CHRISTENSEN. In the final stages of the culture, twelve weeks after collection, all the oogonia were completely sessile with only one to each antheridium. The culture was then feebly producing its third crop of reproductive organs. *V. de Baryana* was collected at Ardmore on eight different occasions and once from Mannin bay. Each collection from Ardmore was kept in culture. Nearly all cultures survived through three stages of reproduction which regularly alternated with sterile periods. The pattern in each case was similar, as the culture aged the oogonia became sessile and reduced to one per antheridium. In three to four months old cultures, the antheridia were no longer terminal but were on very short lateral branches which originated from the same part of the filament as did the short oogonial branches (cf. fig. 8). This variation is similar to that illustrated by RIETH (1965, p. 504, fig. c). This «unhealthy» state was also common in a sample at the time of its collection from Mannin bay. This sample was not in good condition as it looked brown in colour and was almost completely devoid of chlorophyll at the time of collection. In some samples collected at Ardmore which formed only loose threads, the oogonia present at the time of the collection were frequently almost sessile. Proliferation was only observed three times (fig. 9). Branches with deformed antheridia and oogonia occured in the latter stages of culturing but were never frequent. In these cases the shape of the antheridia and oogonia were recognisable but they were not cut off (fig. 10-14). Although the reproductive organs changed with the age of the culture they were always recognisable as those of *V. de Baryana*. This was especially true of the antheridium which only altered slightly in shape (fig. 15). The antheridial stalk was never hooked as illustrated by RIETH and CHRISTENSEN and mentioned by VENKATARAMAN. No other form of reproduction was ever observed in this species. The width of the filaments always remained within the original limits of 20-50 μm.As stated by VAUCHER (1803), these dimensions are «very much finer than those of *V. geminata* and all the dimensions of its fruiting organs are about half of those found in *V. geminata*».

b. *VAUCHERIA GEMINATA* (VAUCH.) DE CANDOLLE. (fig. 16-23).

In may 1969 *Vaucheria* was collected from a second location at Ardmore coral strand. The species was identified as *V. de Baryana* by the reproductive organs present and the filament width (18-48 μm). However, a large portion of the filaments varied in width from 40-110 μm. After three weeks in culture these

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filaments became fertile and were identified as *V. geminata*. The *V. de Baryana*, which was extremely fertile at the time of collection and even had numerous oospores germinating *in situ*, died off after two weeks and did not recover. These two species were found intermingled in at least seven different samples from Ardmore and in one sample from Mannin Bay. CHRISTENSEN (1969) also records *V. de Baryana* growing mixed with several other species but does not include *V. geminata* among them. At Carraroe *V. geminata* was frequently found growing on the coral sand but it was never accompanied by any other species.

The *V. geminata* was identified from the descriptions and illustrations of VENKATARAMAN (1961), and CHRISTENSEN (1969). The cylindrical circinate antheridium was terminal, on a short stalk and opened by a single large terminal pore. It was situated between two oogonia which were on short lateral branches. The oogonia were flat or concave on one side and had a small beak facing the antheridium. In one collection the darker green centre of the material was more fertile than the paler edges. The oogonia were on longer branches but were smaller in size and measured from 65-80 μm in width in the darker central parts, whereas those on the shorter branches in the paler portions measured from 90-120 μm in width. *V. geminata* frequently survived in culture for over three months. A second and third stage of sexual reproduction was observed but the reproductive organs did not alter much, except for a tendency to reduce the number of oogonia to one per antheridium in a few cases and a tendency towards more sessile oogonia. The fruiting organs did not alter with age as much as in *V. de Baryana* and neither was the alternation of fertile and non fertile phases as pronounced. Proliferation of branches showing as many as five pairs of sessile oogonia was observed in cultures after three months but was never abundant. It was, however, very common in one collection from Carraroe in which *Vaucheria* was extremely fertile as a result of having been covered by the sand, following submersion by a high tide (fig. 16, 17). In rare cases in old cultures the antheridial branches were extremely short and swollen into broad triangular shapes as much as 210 μm wide but oogonia were never observed in such cases (fig. 18).

After nearly four months in culture the filaments had not altered their width beyond the original 40-110 μm but they eventually broke up into short thick walled irregular pieces or akinates. These were very common in old cultures of this species. Aplanospores were observed at various stages of culturing. They were oval in shape and measured 68-119 by 119-153 μm.

c. *VAUCHERIA SESSILIS* (VAUCH.) DE CANDOLLE. (fig. 24-29).

On june 26 1969 it was noticed that at the entrance to Ardmore strand low down on the shore, within fourteen feet of the then high tide, the coral sand was coloured red by the iron seepage. Although no *Vaucheria* was visible a sample of the sand was kept in the laboratory and after a few days it revealed two species : *V. geminata* and *V. sessilis*. These two species could only be distinguished by

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their fruiting bodies as the filaments of the former varied from 35-95 μm in width and those of the latter varied from 30-92 μm.

The *V. sessilis* agreed with the description given by CHRISTENSEN in that «the species varied a good deal with regard to the direction of the beak of the oogonium and the width of the filaments, and the tendency to form only one oogonium near each antheridium». The cylindrical antheridium is either circinate or rarely straight, erect or coiled downwards and it opens by a single large terminal opening. The antheridium is either near a single oogonium or situated between two oogonia. The oogonia are either sessile or on very short pedicels and have a short beak which varies in position but usually faces the antheridium.

V. sessilis was collected from the red tinged coral sand at this location on four other occasions. In culture the fruiting bodies remained continuously for up to two months without variation, other than already described and without alternating fruiting periods.

As was the case with the previous species the occurence on the hard brittle coral sand close to the high tide level contrasts with its more usual habitat. CHRISTENSEN for example records it from swiftly running water, on soil at a watercourse, and from stagnant water. As was the case with the samples collected by CHRISTENSEN, the coral sand samples, with the exception of the first, were always fertile at the time of collection.

I. *VAUCHERIA PACHYDERMA* WALZ. (fig. 30-34).

A sample of sand from Ardmore taken in december 1969 was placed in culture and shown to contain *V. de Baryana*. Some wider filaments ranging from 40 to 95 μm in width, became fertile after three weeks and matched the description and drawings of *V. pachyderma* as given by VENKATARAMAN (1961) and CHRISTENSEN (1969). DANGEARD (1939) gives the filament width for this species as being 35-45 μm whereas VENKATARAMAN gives it as 40-123 μm. The latter measurements are more in keeping with those of the coral sand samples. This species is characterised by the extremely thick wall of the oogonium which measured as much as 7 μm in thickness and consists of 5-7 layers. The oogonia varied very much in shape and were sometimes almost spherical and in other cases very flattened and paralleled to the filament. They varied in width from 95-180 μm and in height from 90-140 μm. They were usually sessile or rarely slightly pedicillate. The antheridia matured much earlier than the oogonia and they resembled those of *V. sessilis* in that they were cylindrical, stalked and frequently circinate and were situated next to the oogonium but there was always only one oogonium to each antheridium. The antheridium usually grew downwards. The prominent beak on the oogonium was situated more on the side and often pointed downwards. Collections made in april 1970 from this location contained only *V. pachyderma*.

One collection was made at Streamstown bay. Only a minute amount of

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Vaucheria was present and it never became fertile. Similarly a collection from a coral strand on the western side of Gorumna island never became fertile. However, in both of these cases the filaments were too wide to belong to the species *V. de Baryana*.

e. INTERMINGLING OF SPECIES.

As appears to be typical of *Vaucheria* in general the various species found growing on the coral sand were frequently intermingled with each other as is summarised in the table. At Carraroe however, *V. geminata* was the only species ever recorded. Material collected at Ardmore strand, in october 1969, was kept in crude culture and became fertile after two weeks and was *V. geminata*, two weeks later however the fertile filaments were *V. sessilis*. Some very fine filaments present in the material from the time of collection only became fertile after three months and this species was then identified as *V. de Baryana*. This was the only collection to contain three species and it is of interest that the *V. de Baryana* did not become fertile until after the death of the other two species. By the time it did become fertile the *V. de Baryana* was old and unhealthy in appearance and the reproductive organs present were those typical of old cultures as described earlier and illustrated in fig. 8.

Table 1 : locations of species (+ intermingling species)

Ardmore Entrance	Ardmore offshore	Carraroe	Mannin bay	Gorumna isl. north-eastern side
V. de Baryana	V. geminata	V. geminata	V. geminata	V. pachyderma
V. pachyderma	V. geminata		V. de Baryana	
V. de Baryana	V. de Baryana			
V. geminata				
V. geminata				
V. sessilis				
V. de Baryana				
V. pachyderma				
V. de Baryana				
V. geminata				
V. sessilis				

Grid References, according to Irish Ordonance Survey Maps, sheet 10 (scale 1/2 inch to a mile) :
Carraroe : L. 91 22; Ardmore : L. 82 29; Mannin bay : L. 63 48; Streamstown bay : L. 58 54; Gorumna Island : L. 85 23.

Source MNHN Paris

ACKNOWLEDGMENTS

I wish to thank Professor M. de Valera, University College, Galway, for directing this work and for her kindness and assistance at all times during the preparation of this paper.

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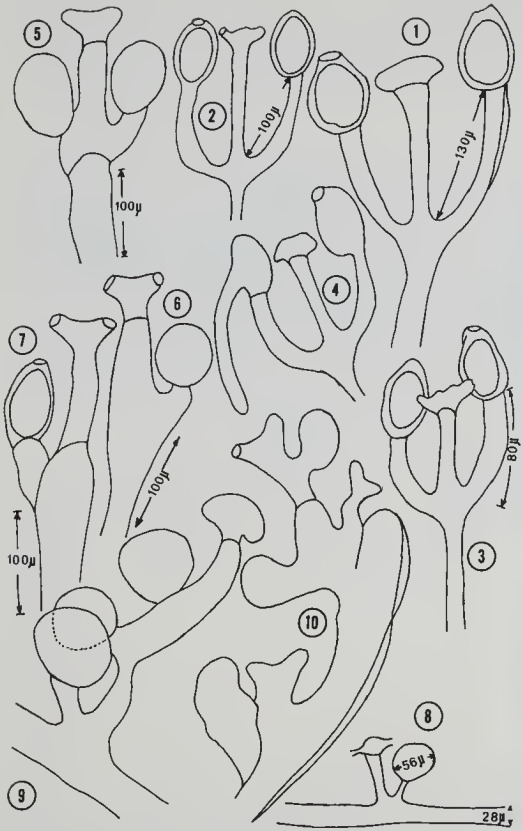
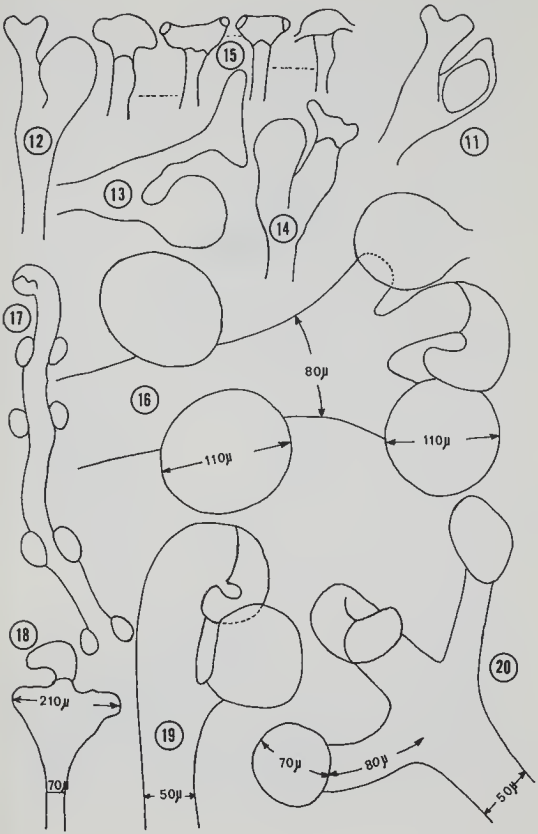


Legends for drawings :

Vaucheria de Baryana : fig. 1-15; *V. geminata* : fig. 16-23; *V. sessilis* : fig. 24-29; *V. pachyderma* : fig. 30-34.

Source MNHN, Paris



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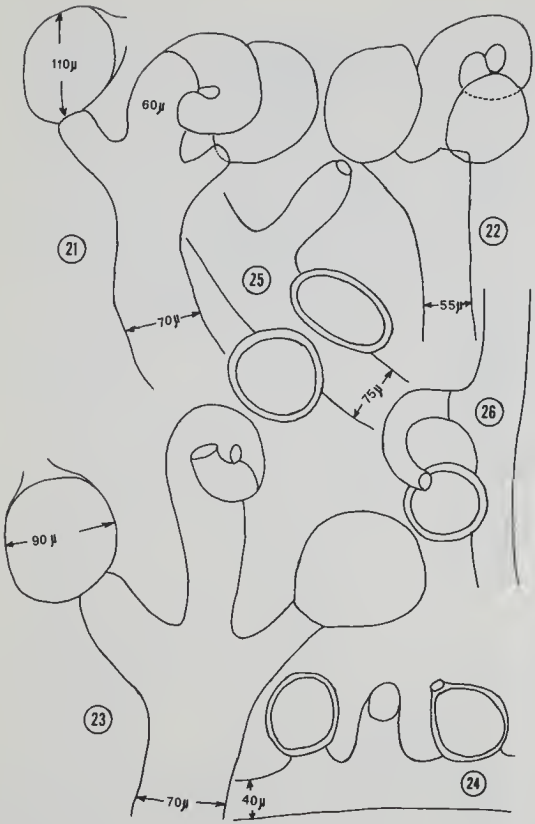

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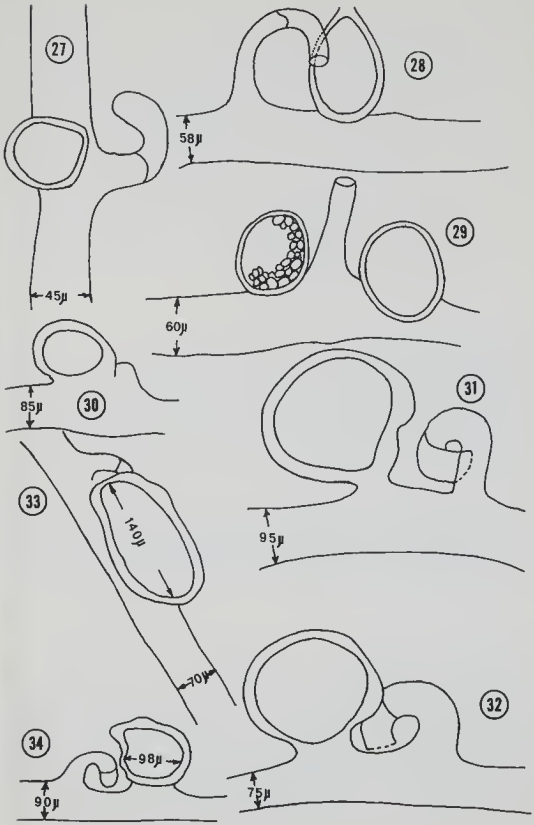

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THE STRUCTURE OF OSCILLATORIA LIMOSA AG. (CYANOPHYCEA) AND THE FORMATION OF HORMOGONIA AND NECRIDIA

A STUDY USING THE LIGHT MICROSCOPE, THE SCANNING AND TRANSMISSION ELECTRON MICROSCOPES

E. FJERDINGSTAD, Bo HOLMA, and Ejnar J. FJERDINGSTAD *

SUMMARY. — The structure and reproduction of the blue-green alga *Oscillatoria limosa* Ag. as seen with the light microscope, the scanning and transmission electron microscopes. The results emphasize the necessity of a higher resolving power than it is possible to obtain with conventional techniques using light microscopy for classifying the blue-green algae according to morphological characteristics, e. g. the formation of hormonia by means of necridia has given rise to erroneous establishment of *Oscillatoria refringens* and *O. lauterbornii fa. calyptra.*

RÉSUMÉ. — L'observation de la structure et de la reproduction de *Oscillatoria limosa* Ag. au microscope photonique ainsi qu'aux microscopes électroniques à transmission et à balayage soulignent la nécessité d'utiliser de fortes résolutions supérieures à celles du microscope photonique pour réussir à distinguer les Cyanophycées d'après leurs caractères morphologiques, comme le prouve la création erronée d'*Oscillatoria refringens* et *O. lauterbornii fa. calyptra.*

1. INTRODUCTION

The appearance of the scanning electron microscope (SEM), which has a higher resolving power (depth of focus about 300 times better than that of the light microscope, cf. GRAY), and in which the image, unlike that of the light microscope, is three-dimensional, has made it possible to study more closely the taxonomically highly significant external structure of the microorganisms. Thus the scanning microscope has been used successfully for the study of Diatoms and Foraminifera, (cf. BARLETT 1967; BE 1968; BENS & DREWS 1967; HAY &

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Rev. Algol., N. S., 1976, XI, 3-4 : 261-272.

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SUNDBURG 1967; HONJO & BERGGREEN 1967), of soil microorganisms by GRAY (1967), of fossil diatoms by MILLER (1969), and of desmids by LYON (1969). Cyanophyceae as *Merismopedia glauca, Anacystis montana*, and *Oscillatoria formosa* have been studied with the scanning electron microscope by ECHLIN (1968), but the figures given by this author provide no useful information on the surface structure since the organisms have been covered by the electron dense layer - a phenomenon frequently observed by the authors of the present article, for instance in the case of *Spirulina major, Oscillatoria chalybea*, and *Phormidium foveolarum* etc. (cf. fig. 1 a-b). Incidentally, BRINGMANN (1950: 557) and METZNER (1955 : 53) state that trichomes of Cyanophyceae in the transmission electron microscope (TEM) are frequently seen to be surrounded by an outer electron dense layer, even at high electron potentials. It is understandable, therefore, that the scanning electron microscope has not as yet been as useful in the study of the morphology and taxonomy of Cyanophyceae as might have been expected. That it is nevertheless possible by means of this technique to disclose structures which cannot be seen with the light microscope will appear from the micrographs of *Oscillatoria limosa* Ag. in the present article. The scanning electron microscope will thus be a valuable supplement to the transmission electron microscope and the light microscope in the study of blue-green algae.

II. MATERIAL AND METHODS

The material studied in the present work was collected two to three years ago from various localities in Denmark. Duplicate samples were collected, one sample was at once fixed in 4% formaldehyde solution, while living cells of the other sample were viewed with the light microscope.

For use with the scanning electron microscope material stored in formaldehyde was used. It was washed in distilled water for 30 minutes, transfered to 60% alcohol for 30 minutes, and to absolute alcohol for 30 minutes. After this, a drop of the concentrated sample was spread as a thin uniform layer on a circular cover glass, 9 mm in diameter, and dried gently. The cover glass with the layer of algae upwards was then secured to a stub with little dab of synthetic glue. Before being viewed with the scanning electron microscope the organisms were coated with a conductive substance (gold) in a vacuum evaporator.

The scanning electron microscope studies were made in collaboration with Analytical A. B., Sollentuna, Sweden.

It is the present authors' experience that Cyanophycea material which has been kept for considerable time in formaldehyde gives better results (no shrinkage) than material which has been fixed for a short time only.

For use with the transmission electron microscope material which had been kept in formaldehyde was washed in distilled water for twelve hours, fixed in buffered 2% osmium tetroxide solution for one hour and embedded in Epon. Sections were cut on a LKB Ultrotome, and the sections were picked up on

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carbon stabilized Parlodion films, poststained on the grid with zinc uranyl acetate + lead citrate and viewed with a Siemens Elmiskop I b. and Carl Zeiss E M 9. The microscope was operated at 40 kV.

This part of the study was made in the Institute of General Zoology.

III. OBSERVATIONS

a. LIGHT MICROSCOPY

GEITLER (1932) describes *Oscillatoria limosa* Ag. as having more or less straight trichomes, usually forming a dark blue-green, brownish or olive-green mass. Trichomes are not, or only slightly, constricted at cross walls, mostly 13-16 μm in diameter, cells are 2-5 μm long, end cells are flat, rounded with thickened membrane - occasionally with sheath formation.

In a recent paper FJERDINGSTAD (1971) has accounted for the results of examinations of a very great number of trichomes of *Oscillatoria limosa* deriving in part from material collected by the author in Denmark, in part from different exsiccate materials, and in part from herbarium materials stored in the Botanical Museum of the Copenhagen University. With regard to the morphological features it appears from FJERDINGSTAD's examinations that in most of the trichomes the outer membrane of the end cell is not thickened. A slight attenuation at the tips was observed in about 50% of the samples, a slight constriction at the cross walls in about 36%, and granules at the cross walls in about 47%. The presence of a firm sheath was observed, however, only infrequently. Most frequently there is a thin, hyaline layer along the outer walls of the trichome corresponding to the thin, mucous sheath occuring in some species of the genus *Phormidium*.

As regards the dimensions of the organisms in the materials dealt with here the diameters of trichomes of *O. limosa* from Ketting brook (fig. 2) were : minimum 12 μm, maximum 19 μm mean, and dispersion 14.5 ± 0.9(8) μm, from a spring in Askemose forest (fig. 5-7) the figures were 10 μm, 16 μm and 12.4(5) ± 0.8(4) μm respectively, and from Lille Holmehave brook 12 μm, 19 μm and 14.5 ± 0.9(8) μm.

Hormogonia are developed through the formation of necridia (fig. 2b, 2d). The septa of the neighbouring cells on both sides of a necridium assume convex shape whereby the protoplasm of the necridium is compressed, and it becomes biconcave. Now the only connection between the neighbouring cells is the circular border of each intervening septum, cp. also KOHL (1903). Laterally a necridium often bulges slightly so as to produce a curve in the otherwise linear outline of the trichome. When the separation between the cells is completed, the necridium dies. Necridia are frequent in the material of *O. limosa* studied in the present work.

A specimen of *O. limosa* with necridia has been described by GARDNER

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(1927), erroneously, as an independent species : *O. refringens* - although GARDNER herself mentions that some trichomes, especially young ones, lack such «refringent» cells, cp. also FJERDINGSTAD (1971).

When the separation at the necridium is completed, remnants of the necridial cell wall may sometimes be found on the outside of the end cell (fig. 2d). Due to erroneous interpretation of this phenomenon a variety of O. *lauterbornii* Schmidle, viz. var. *calyptra,* has been established. According to the figure given by CLAUS (1955) it is not a case of actual calyptra formation, but obviously remnants of a (necridial) cell membrane which has been interpreted as a calyptra. Thus var. *calyptra* Claus should not be considered an independant taxon.

b. SCANNING ELECTRON MICROSCOPY

With lower as well as higher magnification blue-green algae often appear in the scanning electron microscope to be covered with an outer, electron dense layer which appears as a uniform coating (fig. 1 a-b).

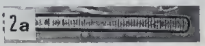
As mentioned in the above, when viewed with the light microscope O. *limosa* showed a slight constriction at the cross walls in about 36% of the material. Viewed with the scanning electron microscope this constriction appears very clearly in specimens in which there is no electron dense layer (fig. 3-4). It appears from fig. 5 that constrictions at the cross walls do not always occur. There are thus two types of O. *limosa*, but no taxonomic significance should be ascribed to this morphological difference, since FRITSCH (1953) in *Phormidium* strata found trichomes with constrictions and trichomes without constrictions, while FJERDINGSTAD (1969) mentions that trichomes of *Anabaena variabilis* may be found with constrictions in one half of the trichomes and none in the other half. The same may be observed in O. *limosa*, cp. FJERDINGSTAD (1971).

In culture experiments with a *Lyngbya* species PEARSON & KINGSBURY (1966 : 198) have shown that the presence or absence of constrictions at the septa is a characteristic that often varies, even within the same culture vessel. As early as 1933 WEBER (1933 : 403) stated that in connection with a species as *Calothrix Braunii* Born. et Flah. no weight can be attached to the presence of constrictions at the septa, since filaments with and without constrictions occur

Plate 1

Fig. 1a. — *Spirulina major* Kütz., SEM x 5000; Fig. 1b. — *Oscillatoria chalybea* (Mertens) Gom., SEM x 2000; Fig. 2. — *Oscillatoria limosa* A. from different localities in Denmark, light microscope (a : 560 x, b-d : 875 x); Fig. 3. — *Oscillatoria limosa* with constrictions at the cross walls, SEM x 2000; Fig. 4. — *Oscillatoria limosa* with constrictions at the cross walls, SEM x 6500; Fig. 5. — *Oscillatoria limosa* without constrictions, SEM x 5000; Fig. 6. — *Oscillatoria rubescens* D. C. from Vierwaldstätter See following treatment with diastase and cellulase, SEM x 2000.

Source MNHN, Paris



Source MNHN, Paris

together. This feature is not mentioned by DARLEY (1968 : 177) in connection with the species *Calothrix parietina* Thuret, but following studies of Danish materials the present authors are able to confirm that WEBER's observation applies also to this species.

Formation of hormogonia occurs as a result of the development of necridia, see in the above. The lateral bulge of the necridium influences either the preceding or the subsequent cell or both so as to cause a protrusion of the middle part of the new end cell, while at the same time there is a constriction of the sides which is greater than in the other cells in the trichome. This phenomenon, which with the light microscope is frequently only just visible, appears very clearly viewed with the scanning electron microscope (fig. 5).

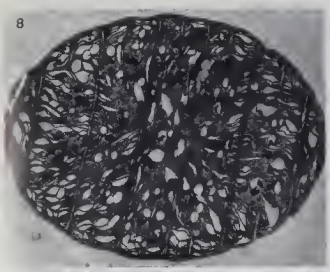
The outer structure of the trichome surface is another detail which is disclosed by the scanning electron microscope. In *O. limosa* this surface consists of regular, vertical, parallel ribs connecting the septa of the cells and a horizontal band in the middle of the cell connecting the side walls of the trichome. This band is probably located at the point where a future cell division might take place (fig. 4).

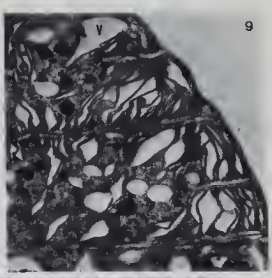
Preliminary studies have shown a corresponding structure in *O. animalis* Ag. *O. tenuis* Ag., and *Oscillatoria* species from Greenland, and in *Phormidium autumnale* (Ag.) Gom, while the structure of *O. rubescens* de Candolle differs from that of the above mentioned in that it is netshaped with irregular, angular meshes of varying size and appearance (fig. 6). In *Symploca muscorum* (Ag.) Gom. and in *Hydrocoleus* the structure corresponds closely to that of *O. limosa*. In *Petalonema*, which belongs to the family Scytonemataceae, there are, on the other hand, wavy cross ribs which connect the side walls of the trichome and are more or less parallel to the septa. Whether decisive taxonomic significance should be ascribed to the difference in structure will only appear after further studies, but it is a reasonable assumption that it will be of significance, particularly to the arrangement of blue-green algae in families, since species of the genera *Oscillatoria, Phormidium, Symploca,* and *Hydrocoleus* which all belong to the family Oscillatoriaceae have the same structure. If this holds good, a species as *O. rubescens* cannot rightly be referred to the genus *Oscillatoria*.

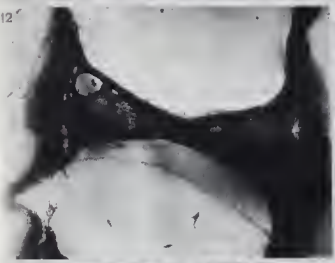
Plate 2

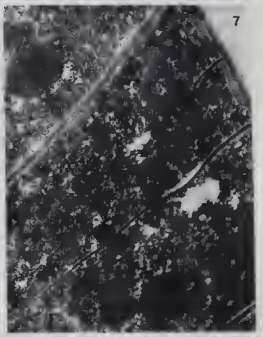
Fig. 7. — *Oscillatoria limosa* showing the photosynthetic apparatus, small osmiophilic granules (ribosomes, lipid granules, polyphosphate granules and incipient cell division, TEM x 6000; Fig. 8. — *Oscillatoria limosa*, oblique section, TEM x 9000; Fig. 9. — *Oscillatoria limosa*, detail of fig. 8, aging cells with many vacuoles and lipid granules, TEM x 19500 Fig. 10. — *Oscillatoria limosa* showing the clubshaped thickenings at the trichome membrane, TEM x 60000; Fig. 11. — *Oscillatoria limosa*, formation of necridia, TEM x 5800; Fig 12. — *Oscillatoria limosa*, a later stage of necridium formation with incipient vacuolation, TEM x 16250; Fig. 13. — A young hormogonium of *O. limosa* (oblique section), TEM x 16250.

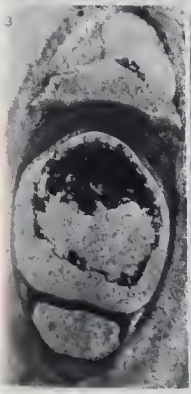
Source MNHN, Paris











Source MNHN, Paris

c. TRANSMISSION ELECTRON MICROSCOPY

The internal structure was studied by transmission electron microscopy. As it appears from fig. 7 the morphological form of the photosynthetic apparatus is lamellar, each lamella consisting of two membranes confining a space of variable width. This closed sac, mostly 16.6 to 20 nm broad, has been termed a thylakoid. The lamellae are situated next to the membranes at the side walls. According to ECHLIN (1965 : 149) the number and arrangement of the lamellae show considerable species variation, ranging from tightly packed stacks to a reticulum. However, variation occurs also according to the age of the organism (ECHLIN 1964).

Among the thylakoids there are some small osmiophilic bodies which are globules of lipid, much larger lipid globules, up to 350 x 416.6 nm, are to be found scattered in the cells (fig. 7).

Ribosomes are small, dense granules occuring in very great numbers in any cytoplasmic space which is not occupied by other components (LANG 1968 : 36).

Vacuoles appear in some micrographs in great numbers, in others there are only very few. According to LANG vacuolation becomes more pronounced in aging cells (fig. 8-9).

NIKLOWITZ & DREWS (1957) mention the presence of a clubshaped thickened border line at the place where side walls and septa join. HAGEDORN (1961 : 826), who studied material fixed in potassium permanganate, confirmed the presence of this clubshaped thickening, but says that it does not represent any expansion of the membrane. As appears from fig. 10, our micrographs do not show any clubshaped thickening of this type where longitudinal wall and cross wall join, but in each cell there are thickenings which do not touch the cross walls. Their dimensions are 66.6 nm wide by 250 nm long. In the space between them cell division takes place.

Formation of hormogonia through necridia is seen clearly in fig. 11-13.

IV. DISCUSSION

As mentioned in the above, it was stated as early as 1903 by KOHL that species of *Oscillatoriaceae* and *Scytonemataceae* form hormogonia through necridia rather than through the septa between living cells. CROW (1925 : 41) mentions the formation of hormogonia in *Lyngbya nigra* Ag. through the development of necridia and writes that «their formation is not preceded by a fissure of the protoplasm, division is merely a result of their formation». In his comprehensive studies of *Oscillatoria amoena* FUHS (1958 : 523) observed only transcellular breakage of trichomes, while HALL & CLAUS (1962 : 360) with regard to the hormogonium formation in *Oscillatoria chalybea* writes that «there is a strong indication that the filaments break up by cleavage between the two mem-

Source MNHN, Paris

branes of the interval». These membranes should thus become the outer membranes of the wall of the newly formed end cells at the site of the previously existing cross wall. When HALL & CLAUS further write that «this explanation would eliminate the theory of FUHS requiring the death of a cell intermediary between two nascent hormogonia» we do not agree with these authors as far as *O. limosa* is concerned since our micrographs, both in scanning and transmission electron microscopy, clearly show the cooperation of necridia in the formation of hormogonia. Nor could LAMONT (1969 : 241) after electron microscopic examination of a *Lyngbya* species (identified according to DROUET as *Microcoleus vaginatus* (Vauch.) Gom.) find evidence for the hypothesis advanced by HALL & CLAUS, and he refers quite rightly to the fact that even HALL & CLAUS's fig. 1 does not support their claim that a septum of *O. chalybea* may split symmetrically to yield an intact cell on either side. HAGEDORN's (1961 : 827) examinations of *O. limosa* also show that hormogonium formation takes place by means of necridia and, unlike HALL & CLAUS, this author writes that in spite of the fact that cell cross walls consist of three layers, they cannot split, but form a morphological unit. Even after treatment with enzymes as trypsin, pepsin, diastase, papain or with acids, bases, or salts it was impossible for HAGEDORN to effect a separation of the layers. As regards *Porphyrosiphon Notarisii* RIS & SINGH (1961 : 65) postulate «that during the hormogonia formation the cross walls split down the middle and show a peculiar grid-like pattern at the point of separation», but the figure (fig. 8) given by the authors does not appear to confirm this assertion.

In 1962 GIESY (1962) published his observation of the ultra structure in *O. limosa* Ag. However, he describes this alga as a filamentous alga with trichomes ranging from 2 to 6 μm in diameter - «each cell is approximately 2 μm thick». If the dimensions mentioned do not represent an erratum, this cannot be a specimen of *O. limosa* the diameter of which is 10-22 μm, rarely more than 22 μm, see in the above. It may be mentioned in this connection that the value of electron microscopic examinations of organisms using DROUET's (1968) highly simplified nomenclature is small if the conventional nomenclature is not given at the same time.

As mentioned in the above, ECHLIN (1965) has pointed out that the structure of the lamellar photosynthetic apparatus is species specific, and the examinations made hitherto and being made at present by the present authors seem to confirm this assertion. ECHLIN (1968 : 138) further says «that it may be possible, solely on structural grounds, to consider as blue-green algae those organisms which possess peripheral photosynthetic lamellae while, conversely, the absence of these structures would indicate that the organisms were bacteria». If biochemical demonstration of the presence of c. phycobilins is added as an indicator of blue-green algae, «this will begin to delineate the group from other organisms». CRESPI et al. (1962) write that the action of lysozyme on the different species differ, some species, for instance *O. tenuis* and *Phormidium luridum*, are highly sensitive to treatment with this enzyme while other species, for instance *O. formosa*, are not influenced by it. They suggest, therefore, that sensitivity to lysozyme may be of taxonomic value.

Source MNHN, Paris

It may be mentioned that in experiments on the influence of diastase and protease in progress at present we have likewise found the sensitivity of the individual species to these enzymes to differ greatly.

It would not be realistic to base a revision of the taxonomy of blue-green algae solely on light microscopic features, even though determinations of the range of variability of the width and length of trichome cells with statistical determination of mean and dispersion would be highly valuable. The information which may be obtained by means of scanning electron microscopy of the highly significant outer structure as well as the visualization of the internal structure provided by transmission electron microscopy, possibly supplemented by biochemical analyses, should also be utilized.

V. CONCLUSIONS

Structural features of *O. limosa* Ag. were studied with the light microscope as well as with the scanning and the transmission electron microscopes.

Hormogonia formation takes place through the development of necridia, and this has given rise to erroneous establishment of the species *O. refringens* Gardner and *O. lauterbornii* Schmidle *fa. calyptra* Claus.

The scanning electron microscope shows that the trichome surface in *O. limosa* has a peculiar structure which is also observed in other *Oscillatoria* species, with the exception of *O. rubescens*, and in other species belonging to the family Oscillatoriaceae. This structure differs from the structure in *Petalonema* of the family Scytonemataceae. It is reasonable to assume that the outer structure of the trichome may be utilized for systematical purposes in distinguishing between the families of blue-green algae. If so, it cannot be correct to refer *O. rubescens* to the family Oscillatoriaceae.

As regards the observation by NIKLOWITZ & DREWS (1957) of a clubshaped thickening at the point where the side wall adjoin the cross wall, an observation confirmed by HAGEDORN (1961 : 826), we have been unable to trace this phenomenon in our TEM micrographs.

It is finally mentioned that a revision of the taxonomy of Cyanophyceae should also take into consideration the information which scanning electron microscopy and transmission electron microscopy may provide with regard to the outer and inner structure of blue-green algae, possibly supplemented with biochemical tests.

Source MNHN, Paris

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ETUDE COMPARATIVE DES CYCLES DU LIAGORA TETRASPORIFERA BØRG. ET DU LIAGORA DISTENTA (MERT.) C. AG. EN CULTURE.

A. COUTÉ *

RÉSUMÉ. – Alors que le *Liagora distenta* a un cycle trigénétique hétéromorphe avec un tétrasporophyte nain bien individualisé, le *Liagora tetrasporifera* a un cycle digénétique hétéromorphe sans tétrasporophyte, les carpotétraspores produisant un nouveau gamétophyte. Les cycles morphologiques de *Liagora distenta* et *Liagora tetrasporifera* ont été étudiés sur des cultures réalisées en lumière du jour naturelle à la température de 12° C.

SUMMARY. – The morphological cycles of *Liagora distenta* and *L. tetrasporifera*, grown in cultures at 12° C in daylight, are compared. *L. distenta* shows true alternation of generations as do most of the Nemalionales studied with a trigenetic heteromorphous cycle with a tetrasporophyte. *L. tetrasporifera* has a digenetic heteromorphous cycle without tetrasporophyte.

1. INTRODUCTION

Après les travaux de SVEDELIUS et de KYLIN on a longtemps considéré les Némalionales comme haplobiontes, c'est-à-dire comme des individus portant des carposporocystes, en admettant que les carpospores produisaient directement les gamétophytes, le zygote subissant la méiose. Dans ces conditions, leur cycle était digénétique et haplophasique.

Mais les recherches cytologiques de MAGNE ont montré que les carpospores sont diploïdes et ont laissé supposer l'existence d'un tétrasporophyte, inconnu jusque-là, libérant des tétraspores haploïdes. De nombreux auteurs ont confirmé les recherches de MAGNE en mettant en évidence l'existence d'un tétrasporophyte nain, réduit à un thalle hétérotriche (= «Nématothalle» de CHADE-

Ce travail a constitué la partie principale d'une thèse de doctorat de 3e cycle soutenue le 19 juin 1972 à l'Université de Paris VI. La bibliographie ne comporte donc pas de références ultérieures à cette date.

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Rev. Algol., N. S., 1976, XI, 3-4 : 273-297.

Source : MNHN, Paris

FAUD) engendré par la germination de la carpospore. Ce fut ainsi le cas de VON STOSCH avec le *Liagora farinosa* Lamour. (1965), UMEZAKI avec le *Nemalion vermiculare* Suringar (1967) et plus récemment avec le *Scinaia japonica* Setchell (1971), FRIES avec le *Nemalion multifidum* (Weber & Mohr) J. Ag. (1967), BOILLOT avec le *Scinaia furcellata* (Turner) Bivona (1968, 1969) et avec l' *Helminthora divaricata* (C. Ag.) J. Ag. (1971), et enfin RAMUS avec le *Pseudogloiophloea confusa* (Setchell) Levring (1969). VON STOSCH, de plus, avec le *Liagora farinosa*, a démontré que la méiose a lieu dans le tétrasporocyste, lors de la formation des tétraspores, comme chez les autres Floridées.

Toutefois restait posée la question de certaines algues chez lesquelles le contenu des carposporocystes subit une division en quatre, engendrant ainsi quatre carpotétraspores. Pour l'ensemble du globe, on en compte actuellement huit qui se répartissent en trois genres : *Liagora tetrasporifera* Börg. (BØRGESEN, 1927), *L. pinnata* Harvey (YAMADA, 1938), *L. brachyclada* (Decaisne) Montagne (LEVRING, 1941), *L. papenfussii* Abbott (ABBOTT, 1945), *L. harveyana* Zeh (WOMERSLEY, 1965), *Helminthocladia hudsoni* (C. Ag.) J. Ag. (FELDMANN, 1939), *H. senegalensis* Bodard (BODARD, 1971) et enfin *Yamadaella cenomyce* Abbott (ABBOTT,1970).

Le remarquable travail de BØRGESEN sur le *Liagora tetrasporifera* (1927) avait conduit à admettre, malgré les points de vue contraires de SVEDELIUS et de KYLIN, sans preuve, que les divisions nucléaires aboutissant à la formation des noyaux des carpotétraspores constituaient une méiose et que les carpotétraspores haploïdes redonnaient directement un gamétophyte.

Très récemment, BODARD (1971) a démontré avec l'*Helminthocladia senegalensis*, que la division du carposporocyste engendrant les quatre tétraspores, est une méiose. Cependant il restait encore à préciser, chez ces algues à carpotétraspores, l'alternance de générations. Ce fut le but de ce travail.

Ayant eu la chance de récolter, au cours de plongées effectuées entre Banyuls-sur-mer et Cerbère, au mois de septembre 1969, 1970 et 1971, le *Liagora tetrasporifera* pourvu de carpotétraspores, nous en avons entrepris des cultures dans l'espoir de résoudre le problème du rôle de la carpotétraspore et de son devenir. A la même époque, ayant récolté une autre espèce du même genre, le *Liagora distenta*, qui elle possède des carpospores indivises, nous avons tenté aussi d'en réaliser des cultures pour établir une étude comparative entre ces deux espèces. La culture de cette deuxième espèce présentait aussi un autre intérêt, à savoir qu'elle permettait de faire une comparaison avec les résultats obtenus par VON STOSCH avec le *Liagora farinosa* (1965) qui possède également des carpospores.

II. MATERIEL ET MÉTHODES

Le matériel qui a servi à la mise en route des cultures a été exclusivement récolté dans la région de Banyuls-sur-mer. Des échantillons ont été trouvés aussi bien près du cap Béar, de l'anse des Elmes, qu'au voisinage du cap du Troc, du cap l'Abeille et de l'anse de Terrambou, toujours dans les localités assez abritées

Source MNHN, Paris

et à une profondeur n'excédant pas, ou rarement - 5 m. La fertilité des échantillons n'a été constatée qu'entre les mois d'août et septembre pour les années 1969, 1970 et 1971. D'autre part, aucun thalle n'a jamais été observé avant le mois de mai, ce qui revient à dire que ces algues sont annuelles. La durée de vie de leur forme macroscopique est très réduite, les thalles disparaissent à la mi-octobre. Cette caractéristique a constitué une difficulté supplémentaire majeure pour leur étude.

Ces observations, toutefois, sont propres à la région de Banyuls-sur-mer, car, en ce qui concerne le *Liagora tetrasporifera*, BØRGESEN signale avoir trouvé des échantillons fertiles aux Iles Canaries au mois de mars.

Après la récolte, les échantillons sont rapidement rapportés au laboratoire pour préparer immédiatement les cultures. Les apex fertiles des thalles sont sélectionnés sous la loupe binoculaire. On les reconnaît aisément à la présence de renflements rouge foncé sur la croûte blanche du *Liagora tetrasporifera*, rose chez le *Liagora distenta*. Ces formations traversant la croûte calcifiée du thalle et affleurant à sa surface, sont constituées par les gonimoblastes portant à l'extrémité de leurs filaments les carpotétraspores chez la première espèce et les carpospores chez l'autre.

Ces apex, une fois isolés, sont déposés sur des lames de verre préalablement dégraissées et stérilisées, de préférence à la surface non lisse (afin de faciliter l'implantation des jeunes germinations), immergées dans un bac rempli d'eau de mer fraîche, filtrée sur papier. On abrite contre les poussières, la lumière trop vive et une température trop élevée, les échantillons générateurs de spores et on laisse ainsi durant quarante huit heures pendant lesquelles les spores sont libérées et s'implantent sur les lames. Ces dernières avec les spores fixées sont ensuite débarrassées des fragments macroscopiques et disposées dans des boîtes de Petri stérilisées remplies à demi de milieu de VON STOSCH modifié (1964) dont la composition est la suivante :

$NaNO_3$	: 42,5 mg/litre eau de mer
$Na_2HPO_4 + 12\,H_2O$	: 10,75 mg/litre eau de mer
$FeSO_4 + 7\,H_2O + 0{,}01$ ml H_2SO_4 conc.	: 0,278 mg/litre eau de mer
$MnCl_2 + 4\,H_2O$	: 0,0198 mg/litre eau de mer
E. D. T. A.	: 3,72 mg/litre eau de mer
Cobalamine (B 12)	: 0,0007 mg/litre eau de mer
Aneurine HCl	: 0,0086 mg/litre eau de mer
Biotine	: 0,0061 mg/litre eau de mer
IH	: 0,664 mg/litre eau de mer
As_2O_3	: 0,197 mg/litre eau de mer

A ce milieu de culture a été ajouté, à raison de 5 ml par litre, une solution d'oxyde de germanium (WEST, 1969) dont le rôle est d'empêcher la prolifération des diatomées.

Les jeunes germinations sont éclairées en lumière du jour naturelle; des essais nombreux, réalisés avec des éclairements variés, mais sans tenir compte de la longueur d'onde, ont mis en évidence que les meilleurs résultats étaient toujours

Source MNHN Paris

obtenus en fournissant aux cultures la lumière du jour ou des éclairements très voisins.

En ce qui concerne les températures auxquelles les algues sont soumises, ce sont les valeurs situées entre 12° et 15° C qui sont les plus favorables à leur bon développement, avec un rendement maximal pour la valeur de 12°.

Après deux à trois semaines de séjour dans ce milieu, nécessaires pour faire disparaître totalement les diatomées, les jeunes individus sont transplantés à l'aide d'une micropipette dans de nouvelles boîtes de Petri contenant du milieu de VON STOSCH normal, sans germanium. Cette transplantation est indispensable pour isoler les germinations des nombreuses algues épiphytes implantées en même temps que les spores, qui, si l'on se contentait seulement de changer de milieu, risqueraient, en se développant, d'entraver les cultures. On est ainsi parvenu à obtenir des cultures unialgales.

Après la transplantation les milieux ont été régulièrement changés tous les mois.

III. RÉSULTATS

A. COMPARAISON MORPHOLOGIQUE ET ANATOMIQUE DES DEUX ESPECES.

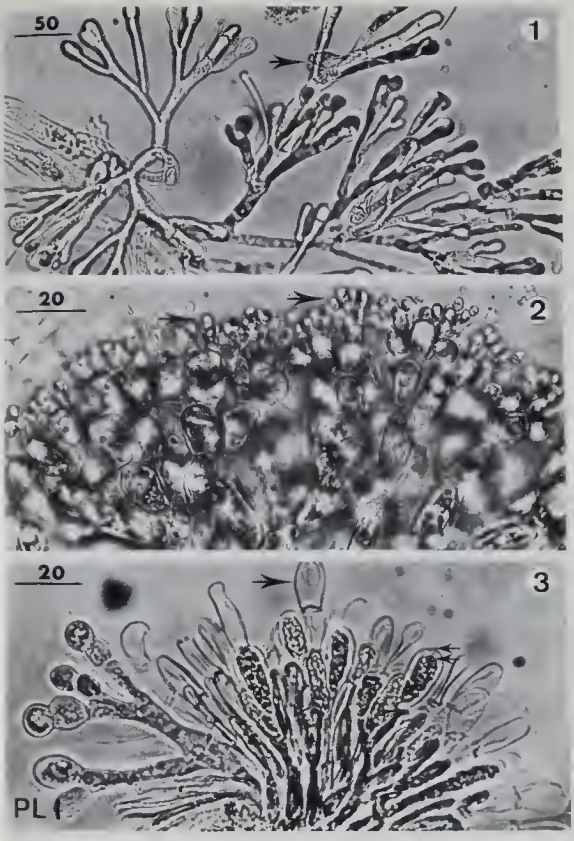
On peut très facilement distinguer le *Liagora distenta* du *Liagora tetrasporifera* grâce à deux caractères, l'un morphologique, l'autre anatomique. Les deux espèces présentent, en effet, toutes deux une dichotomie générale de leur thalle mais, chez le *Liagora distenta* des petits rameaux supplémentaires apparaissent de façon constante sur l'axe du thalle, ce qui n'est pas le cas chez le *Liagora tetrasporifera.*

Anatomiquement on peut aussi séparer une espèce de l'autre, en particulier en observant des coupes transversales des thalles. Chez le *Liagora distenta* les cellules de l'axe se distinguent nettement des rhizoïdes : leur diamètre est, en effet, cinq fois plus grand et leur paroi beaucoup plus mince que celles des cellules rhizoïdiennes, très réfringeantes. Par contre chez le *Liagora tetrasporifera* les cellules axiales se distinguent difficilement des cellules rhizoïdiennes : leur diamètre est à peine deux fois plus grand et leur paroi très épaisse de sorte que l'on a du mal à séparer les rhizoïdes des cellules de l'axe.

B. COMPARAISON DES APPAREILS SEXUELS DES DEUX ESPECES.

Les deux espèces étudiées ici diffèrent par leur mode de reproduction; en effet, le *Liagora tetrasporifera*, très clairement décrit par BØRGESEN (1927), est monoïque, c'est-à-dire que l'on trouve, réunis sur le même thalle, les rameaux carpogoniaux et les spermatocystes (Pl. II, fig. 4), alors que le *Liagora distenta* est dioïque, certains thalles ne portant que des rameaux carpogoniaux

Source MNHN, Paris



Pl. I. — 1 : *Liagora distenta*, portion de thalle femelle avec rameau carpogonial (flèche). 2 : *L. distenta*, portion de thalle mâle avec spermatocystes (flèches). 3 : *L. distenta*, gonimoblaste avec carposporocystes, soit vides (flèche simple), soit contenant la carpospore (flèche double).

Toutes les échelles sont exprimées en μm.

Source MNHN, Paris

(Pl. I, fig. 1) d'autres seulement des spermatocystes (Pl. I, fig. 2). Cette particularité du *Liagora distenta* n'a été nettement mentionnée, jusqu'alors, que par un seul auteur, HAMEL (1930), pour des échantillons provenant aussi de Méditerranée. Des échantillons récoltés à Madère en 1966 par CABIOCH (com. pers.) sont également dioïques. La dioïcité de cette espèce semble donc être un caractère constant.

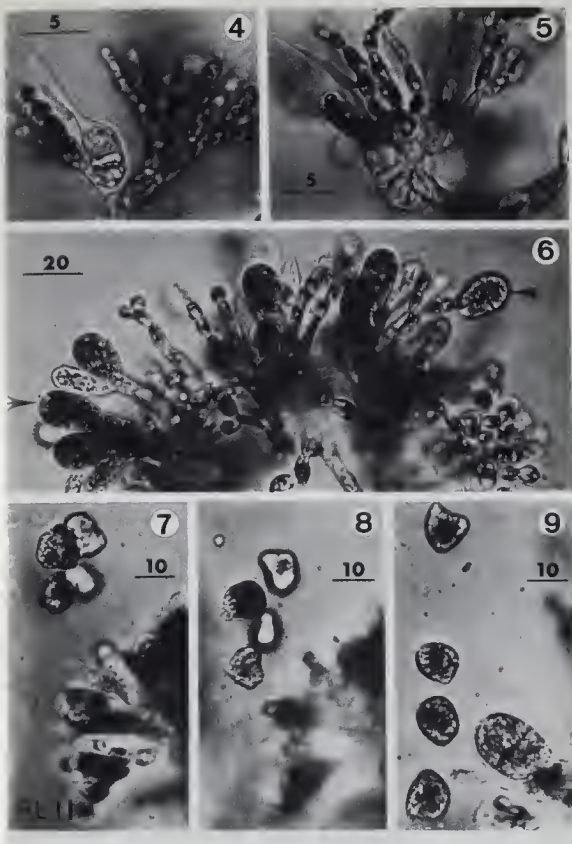
Si l'on considère maintenant les rameaux carpogoniaux des espèces concernées, peu de différences sont à noter. Ils sont respectivement portés par une cellule d'un rameau de filament assimilateur, non distincte cytologiquement. Les uns comme les autres sont composés de quatre à cinq cellules (BØRGESEN, 1927, dans les Algues marines des Canaries, mentionne, pour le *Liagora tetrasporifera*, uniquement trois cellules pour le rameau carpogonial), dont l'aspect, bien que très hyalin par absence de toute pigmentation, laisse supposer une grande richesse en réserves, étant données les très nombreuses petites inclusions sphériques contenues. La largeur des cellules composant l'appareil femelle est d'environ 10 μm pour les deux espèces, mais on peut toutefois constater que les rameaux carpogoniaux du *Liagora distenta* ont un aspect plus trapu que ceux du *Liagora tetrasporifera* dont le carpogone est d'ailleurs plus allongé en général. Pour les deux espèces, le trichogyne s'allonge et apparaît à la surface de la croûte.

Les spermatocystes des deux espèces ne présentent pas non plus de différence nette. Leur diamètre n'excède pas 3 μm ce qui les rend difficilement observables. Ils sont portés par les filaments assimilateurs, à l'apex de rameaux constitués de petites cellules (3 μm de large sur 5 μm de long), de sorte qu'ils sont généralement localisés dans la partie superficielle du thalle.

Après la fécondation, le carpogone subit une première division transversale donnant ainsi une nouvelle cellule à partir de laquelle naissent les filaments sporophytiques du gonimoblaste, composés de cellules grossièrement en forme de tonnelet, de 5 μm environ de côté. Ces filaments constituent un bouquet dense qui apparaît à la surface du thalle comme un petit coussin rouge foncé chez le *Liagora tetrasporifera* (Pl. II, fig. 5) et rose chez le *Liagora distenta* (Pl. I, fig. 3). La plupart du temps, d'ailleurs, l'importance des coussins est due à la fusion des filaments sporophytiques de plusieurs rameaux carpogoniaux fécondés contigus. Chez ces algues on ne voit pas d'involucre autour du gonimoblaste, bien que des filaments stériles, issus de rameaux végétatifs voisins, soient entrelacés avec les filaments gonimoblastiques.

Enfin, à l'extrêmité des rameaux carposporophytiques ainsi développés, composés parfois seulement de deux cellules, prennent naissance des cellules globuleuses dont l'aspect est différent selon l'espèce considérée. Chez le *Liagora tetrasporifera* la formation globuleuse de 8 à 10 μm environ de diamètre, est subdivisée en quatre cellules nommées carpotétraspores (Pl. II, fig. 6); chez le *Liagora distenta* une seule cellule constitue cette formation globuleuse à l'apex du filament gonimoblastique (Pl. I, fig. 3) : c'est un carposporocyste renfermant une carpospore unique, de 10 μm de diamètre et de 20 μm de long environ, son allure générale étant piriforme.

Source MNHN Paris



Pl. II. — 4 : *L. tetrasporifera*, portion de thalle avec rameau carpogonial. 5 : *L. tetrasporifera*, portion de thalle avec un rameau carpogonial fécondé montrant les premiers filaments gonimoblastiques. 6 : *L. tetrasporifera*, gonimoblaste mûr avec carpotétrasporocystes (flèches). 7-8-9 : *L. tetrasporifera*, stades successifs de l'émission des carpotétraspores. Leur forme amiboïde est nette ici.

Toutes les échelles sont exprimées en μm.

Source MNHN Paris

C. EMISSION DES SPORES.

Pour que la comparaison des stades communs aux deux espèces soit plus aisée, nous avons choisi de traiter non pas le cycle morphologique complet de chaque algue successivement, mais de considérer parallèlement les différents stades dans leur suite logique dans le temps, pour les deux espèces, lorsque cela était possible.

Les carpotétraspores du *Liagora tetrasporifera* sont émises très rapidement d'un seul bloc. Elles ne se séparent qu'une fois sorties du carpotétrasporocyste (Pl. II, fig. 7, 8, 9). Leur observation montre alors qu'elles sont plus denses que l'eau de mer car elles tombent au fond du récipient. Elles ne cessent de modifier leur contour pendant un temps assez long (de trois à cinq heures en moyenne) par des déformations amiboïdes. Leur contenu est très dense et pigmenté, sans toutefois qu'on puisse y distinguer un ou plusieurs plastes. Leur taille est d'environ 8 à 10 μm.

Les carpospores du *Liagora distenta* ont la même cytologie que les carpotétraspores du *Liagora tetrasporifera*. Leur taille est légèrement supérieure (10 à 12 μm). Elles sont douées également de modifications amiboïdes pendant quelques heures encore après leur émission. VON STOSCH a observé aussi le même phénomène chez le *Liagora farinosa* (1965).

D. GERMINATION DES SPORES.

a. chez le *Liagora distenta* :

Les carpospores se fixent rapidement au substrat, en l'occurence la lame de verre, auquel elles adhèrent solidement. Vingt-quatre heures après leur fixation, elles se divisent pour donner un filament unisérié. Deux modes de germination sont apparus ici : ou bien la spore se vide de son contenu (comme chez le *Nemalion pulvinatum* (UMEZAKI, 1967), le *Nemalion vermiculare* (UMEZAKI, 1967)...) au profit de la cellule nouvellement formée et dégénère rapidement, ou bien la spore conserve une cytologie normale et participe, comme une banale cellule végétative, à l'édification de la partie prostrée.

Le filament engendré par la spore germante est composé de cellules allongées, de 20 à 30 μm de long sur 5 μm de large. La plupart du temps, ce n'est que lorsqu'il a environ dix cellules qu'on observe les premières ramifications, mais il arrive qu'il s'en forme déjà une alors que le filament n'est encore constitué que de deux ou trois cellules. Les ramifications du filament original sont ensuite très nombreuses, engendrant ainsi un protonéma très enchevêtré. Sur les lames où ont été récoltées les carpospores, on observe d'ailleurs, en général, les nombreux protonémas rouge vif enchevêtrés, issus de chaque carpospore. Ce n'est que sur des carpospores isolées sur la lame de verre lors de l'émission, ou sur des carpospores mises en culture à l'écart à l'aide de la micropipette, que l'on peut bien observer le développement individuel.

Cette partie rampante donne naissance à des filaments dressés unisériés, cons-

Source MNHN Paris

tués de cellules atteignant 40 µm de long et 10 µm de large. Ces cellules, bien que plus longues et plus larges que celles de la partie rampante, ont la même cytologie, à savoir un plaste unique, plurilobé et pariétal, un gros pyrénoïde et de nombreux granules de rhodamylon, qui, très souvent, gênent l'observation. L'allure de la partie dressée est celle d'un *Acrochaetium*. VON STOSCH, en 1965, avait déjà signalé ce fait à propos du tétrasporophyte du *Liagora farinosa* et cela semble être la caractéristique de la plupart des tétrasporophytes des autres Némalionales cultivées jusqu'à présent.

Deux mois environ après la mise en culture des carpospores, les tétrasporocystes sont apparus sur ces filaments dressés du protonéma hétérotriche (Pl. III, fig. 10). Ils se forment, soit à l'extrêmité du filament dressé lui-même, en bouquets denses, soit à l'extrêmité de courts rameaux nés du filament principal. Ils sont sphériques et leur diamètre est d'environ 20 µm (Pl. III, fig. 11). Leur cytologie est très différente de celle des cellules végétatives. En effet, alors que ces dernières ont un contenu très pigmenté, les tétrasporocystes ont un contenu pâle et homogène. On n'y repère ni plaste, ni pyrénoïde, ni granule de rhodamylon, mais la réfringence de la cellule est forte, ce qui laisse supposer une grande richesse en réserves.

Pour les deux raisons énoncées ci-dessus, cette phase du cycle a été difficile à repérer sur le matériel vivant, les tétrasporocystes, petits et pâles, passant la plupart du temps inaperçus à la loupe binoculaire et ce n'est pratiquement qu'à l'objectif à immersion que l'on peut déceler la segmentation en quatre de leur contenu.

Remarquons encore que chez une autre Nemalionale, le *Nemalion vermiculare*, UMEZAKI (1967) a vu apparaître des tétrasporocystes non pédicellés, insérés directement sur le filament dressé du protonéma hétérotriche issu de la germination de la carpospore.

La disposition des tétraspores à l'intérieur du tétrasporocyste est, en général, de deux types : soit tétraédrique, soit cruciée, alors que chez d'autres Némalionales telles le *Pseudogloiophloea confusa* ou le *Scinaia japonica*, elle peut, en plus des formes précédentes, être, soit décussée, soit zonée.

La durée d'existence des tétrasporocystes est très courte, au plus trois ou quatre jours, ce qui rend encore plus difficile leur observation. Dans les cultures réalisées, il ne s'en est formés que deux fois, une en décembre 1970 et une en juillet 1971, sur des tétrasporophytes issus de carpospores émises et récoltées en septembre 1970. Il n'est toutefois pas exclu que d'autres tétrasporocystes soient nés à d'autres périodes de l'année et soient passés inaperçus, pour les raisons données ci-dessus. D'autre part, s'il n'y a eu effectivement que deux périodes de fertilité des filaments tétrasporophytiques, c'est que, peut-être, les conditions de milieu n'ont pas été favorables. Il n'a pas encore été possible, en effet, de préciser les conditions d'apparition des tétrasporocystes, ceci pour des raisons de temps et de matériel. Des essais sont toutefois en cours, basés sur les résultats de FRIES (1967) qui constate l'induction de l'apparition des tétrasporocystes chez le *Nemalion multifidum* lorsque le taux des phosphates

Source MNHN, Paris

Pl. III – 10 : *L. distenta*, tétrasporocyste. 11 : *L. distenta*, portion de rameau tétrasporophytique avec un tétrasporocyste mûr et deux immatures. 12 : *L. distenta*, tétrasporocystes immatures non segmentés et tétrasporocystes vides dans lesquels de nouvelles cellules repoussent.

Toutes les échelles sont exprimées en μm.

Source MNHN Paris

diminue, et sur les très brillants résultats de RAMUS (1969) avec le *Pseudogloiophloea* où les tétrasporocystes apparaissent en grand nombre lorsque la concentration en nitrates diminue.

Les tétraspores sont libérées groupées, l'apex du tétrasporocyste éclatant. Elles se dissocient rapidement et tombent au fond de l'eau, leur densité étant légèrement plus forte que celle de cette dernière. Comme les carpospores, elles sont, pendant plusieurs heures, l'objet de déformations amiboïdes. Leur diamètre est d'environ 15 à 20 μm. Parfois, on trouve des tétraspores plus volumineuses, ce fait étant dû à une turgescence momentanée (Pl. IV, fig. 13 et 14). Cet état turgescent des spores est favorable à l'observation du plastidome qui apparaît composé de plusieurs plastes étoilés, munis chacun d'un gros pyrénoïde bordé de massifs granules de rhodamylon.

Après émission des tétraspores, la paroi apicale du tétrasporocyste vide s'effondre, tandis que, la plupart du temps, une nouvelle cellule croît dans l'ancienne enveloppe (Pl. III, fig. 12) qui s'est repliée vers l'intérieur. Sur les échantillons en culture, ces repousses ont toujours donné naissance à des cellules de type végétatif. RAMUS, dans le cas du *Pseudogloiophloea confusa* (1969) et UMEZAKI, avec le *Scinaia japonica* (1971), montrent que, dans les tétrasporocystes vides, peuvent se reconstituer de nouvelles cellules capables de donner naissance, à nouveau, à des tétraspores. Rien n'interdit de penser qu'ici il en soit de même.

Par ces repousses végétatives, le tétrasporophyte poursuit sa croissance, se ramifiant activement pour constituer finalement un buisson filamenteux d'un rose intense, pouvant atteindre 2 à 3 cm de haut. Jamais, dans la nature, ces organismes n'ont été rencontrés, mais, il est vrai que nous n'avons jamais eu l'occasion de pouvoir les rechercher à Banyuls-sur-mer en décembre ou janvier. Il faut dire aussi, qu'étant donnée leur petite taille, ils ont facilement pu passer inaperçus et que leur ressemblance avec les espèces du genre *Acrochaetium* a pu entraîner une confusion. Il serait néanmoins très intéressant de les trouver dans la nature pour s'assurer de leur existence réelle et confirmer les résultats des cultures. A ce propos, il faut noter que, seule de tous les algologues ayant démontré l'existence d'un tétrasporophyte dans le cycle d'une Nemalionale, FRIES a réussi à retrouver celui-là in situ (*Nemalion multifidum*, 1969).

La germination des tétraspores s'effectue quelques jours seulement après leur fixation au substrat, parfois même 24 heures après. La première indication de la germination est le développement d'un petit renflement de la paroi de la spore, qui s'allonge pour devenir l'apex du filament initial prostré (Pl. IV, fig. 15). De temps en temps, deux filaments prostrés se développent à partir de la même spore. Ces filaments naissant de la germination de tétraspores sont tout à fait analogues, par leur cytologie et leurs dimensions de cellules, à ceux engendrés par la germination des carpospores. Les cellules qui les composent ont 25 à 30 μm de long sur 7 à 8 μm de large. Elles renferment un plaste unique, étoilé, pariétal, muni d'un gros pyrénoïde. Le jeune filament rampant unisérié se ramifie rapidement, parfois même après la formation de la première cellule, dans le plan du substrat, donnant ainsi naissance à un protonéma rampant, formant, à un stade

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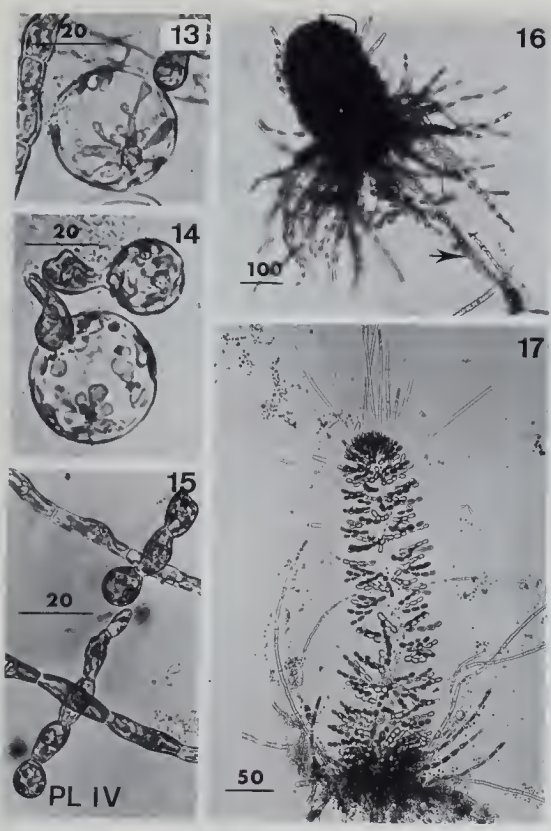

Pl. IV — 13 et 14 : *L. distenta*, tétraspores turgescentes montrant de nombreux plastes plulobés. 15 : *L. distenta*, germination de deux tétraspores. 16 : *L. distenta*, gamétophyte nouvellement formé, à l'extrémité de son filament porteur (flèche), ancien filament dressé du protonéma hétérotriche né de la germination d'une tétraspore. 17 : *L. distenta*, jeune gamétophyte avec sa couronne de poils unicellulaires dans la partie apicale.

Toutes les échelles sont exprimées en μm.

Source MNHN Paris

ultérieur, des filaments dressés. Ce protonéma hétérotriche, de couleur rouge vif, a un aspect tout à fait semblable à celui du protonéma hétérotriche tétrasporophytique. Comme ce dernier, il présente parfois des poils hyalins, unicellulaires, avec une grande vacuole, le cytoplasme n'étant visible qu'à l'apex. Ces poils naissent des cellules rampantes.

Il faut toutefois mentionner que l'extension de ces nouveaux protonémas est plus limitée que celle des protonémas tétrasporophytiques. Cela est-il dû au mode d'entretien des cultures qui souvent a entraîné la fragmentation des filaments, ou cela est-il le fait de l'haploïdie présumée des cellules ? Il est vrai que les filaments, ici, sont constitués de cellules un peu plus petites (25 à 30 μm sur 7 à 8 μm) que celles qui contituent les filaments tétrasporophytiques (40 μm sur 10 μm), diploïdes, elles. Aucune réponse valable n'a pu être encore fournie à cette question.

Les cellules assurant la croissance du protonéma, ou encore les apicales des filaments rampants, ont un contenu très dense mais non pigmenté et sans pyrénoïde distinct.

C'est sur les filaments dressés du protonéma hétérotriche que naissent, à partir d'une ou deux cellules, souvent apicales ou subapicales du filament, des bourgeonnements très denses de rameaux à cellules plus courtes et plus renflées que celles du filament; leur diamètre moyen est d'environ 10 μm. Ce sont ces bourgeons, très compacts, qui engendrent les thalles gamétophytiques. En effet, le bourgeon s'organise rapidement, montrant une zone centrale multiaxiale non pigmentée, faite de cellules très claires, longues de 60 μm en moyenne et larges de 10 μm. Ces cellules, constituant les filaments axiaux, portent à leur partie supérieure un seul rameau fait de cellules très pigmentées, en forme de tonnelet, d'environ 12 μm de diamètre, qui possèdent un plaste pariétal unique plurilobé avec un très volumineux pyrénoïde.

A la base de ce thalle embryonnaire, s'allongent des filaments unisériés, aux cellules longues et étroites (50 μm sur 10 μm), légèrement pigmentées. La disposition de ces filaments est rayonnante, donnant ainsi au jeune thalle un aspect un peu arachnéen (Pl. IV, fig. 16). Ce sont les futurs rhizoïdes, qui constitueront l'appareil fixateur propre du nouvel individu formé, lorsqu'il aura acquis son indépendance.

Ainsi on voit que le thalle gamétophytique ne naît pas directement de la partie prostrée. Chez le *Liagora distenta*, le jeune gamétophyte est donc supporté, dans la première phase de sa vie, par un filament dressé du protonéma hétérotriche, engendré après germination d'une tétraspore. Ce n'est qu'après quelques jours de croissance du nouveau thalle que le filament générateur et porteur va se courber sous la masse grandissante du jeune individu, amenant ce dernier au contact du substrat. Dès cet instant, les rhizoïdes particuliers du nouveau thalle se fixent solidement. Le filament générateur se confond alors avec les rhizoïdes et participe, à son tour, à l'arrimage au substrat. Très souvent, il se brise et dégénère, libérant totalement de son protonéma originel le jeune gamétophyte.

On peut supposer, ici, que la dispersion des thalles et leur propagation dans la

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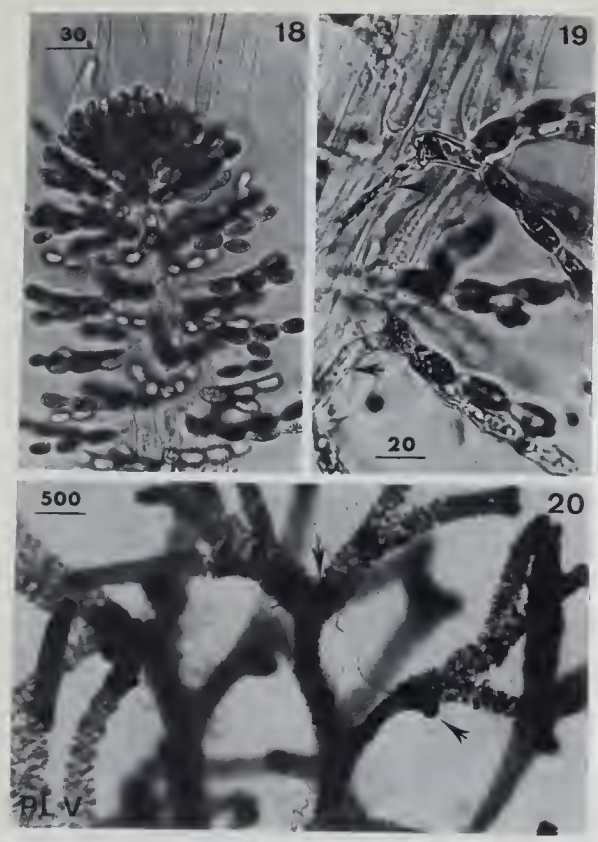


Pl. V – 18 : *L. distenta*, zone apicale d'un jeune gamétophyte. Les filaments latéraux de l'axe apparaissent très clairs alors que les filaments latéraux sont fortement pigmentés. 19 : *L. distenta*, détails de la base de deux filaments latéraux d'un jeune gamétophyte, chacune avec un rhizoïde (flèche). 20 : *L. distenta*, fragment d'un jeune thalle gamétophytique obtenu en culture, présentant de petits rameaux latéraux (flèches) qui sont caractéristiques de cette espèce.

Toutes les échelles sont exprimées en μm.

Source MNHN Paris

nature, sont dues à la fragilité des filaments générateurs qui, sous l'action de la houle, peuvent facilement se briser, libérant ainsi les jeunes individus dont la fixation au substrat sera fonction des courants.

Remarquons, ici, que dans les cultures, tous les thalles formés ne se sont pas toujours présentés au sommet d'un filament porteur, mais bien souvent directement sur une partie rampante réduite. Cette particularité est due au morcellement fréquent des filaments dressés du protonéma hétérotriche, lors du nettoyage des cultures. Les fragments isolés des filaments dressés, à potentialité génératrice de gamétophyte, se fixent et reconstituent une partie rampante réduite parfois à quelques filaments, mais organisée non comme un protonéma mais plutôt comme un cladome (voir le même phénomène chez le *Liagora tetrasporifera*). C'est sur cette partie prostrée que naît le gamétophyte dans de nombreux cas.

Les gamétophytes, dans nos cultures, sont apparus pour la première fois au mois de mars, soit environ six mois après l'émission des carpospores dont ils dérivent (Pl. IV, fig. 17, Pl. V, fig. 18 - 19 - 20).

Il faut noter ici que les résultats obtenus par BOILLOT avec l'*Helminthora divaricata* (1971) en culture, présentent une étonnante similitude avec les nôtres. Mais, comme elle, nous n'avons pu observer avec précision l'organisation des rameaux dont l'association engendre un gamétophyte.

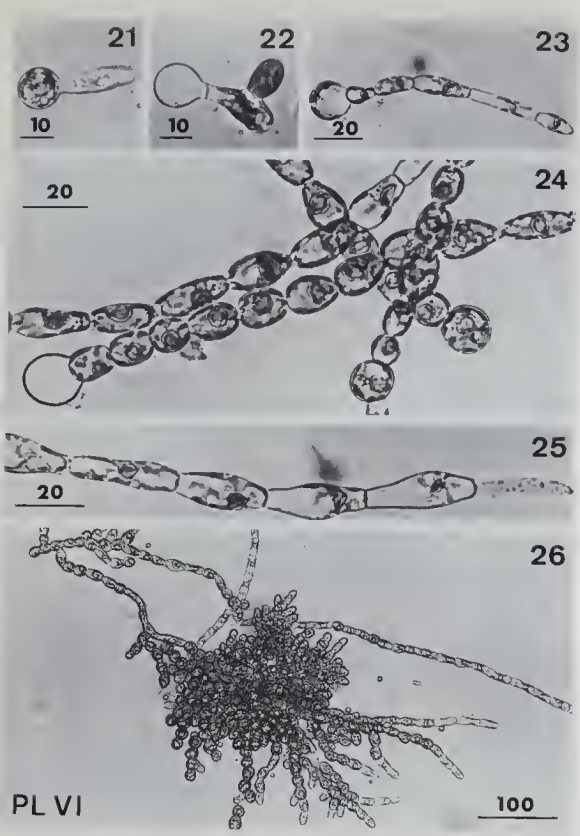
Le *Liagora distenta*, comme le *Liagora farinosa*, possède donc trois générations : un gamétophyte macroscopique différencié en cladome multiaxial, un carposporophyte parasite sur le gamétophyte et morphologiquement très réduit, et un tétrasporophyte nain ressemblant au protonéma du gamétophyte. Son cycle peut donc être défini comme trigénétique hétéromorphe et vraisemblablement haplodiplophasique. Le tétrasporophyte réduit à un thalle hétérotriche, analogue au protonéma juvénile du gamétophyte, peut être considéré comme néoténique.

b. chez le *Liagora tetrasporifera* :

Vingt quatre à quarante huit heures après leur émission, les carpotétraspores germent (Pl. VI, fig. 21), donnant naissance à un filament unisérié, quelques fois à deux. Comme pour le *Liagora distenta*, on observe les mêmes caractéristiques concernant la spore, à savoir qu'elle peut soit se vider et dégénérer après avoir germé (Pl. VI, fig. 22), soit conserver son contenu et persister alors comme une cellule végétative (Pl. VI, fig. 23). Avant leur germination, elles sont aussi l'objet de déformations amiboïdes. Les cellules végétatives du filament de germination renferment un plaste unique, étoilé, pariétal, muni d'un volumineux pyrénoïde, bordé de gros granules de rhodamylon (Pl. V, fig. 24 - 25). Elles ont, en moyenne, 20 µm de long et 15 µm de large. Leur aspect général, tant que le filament n'a que quelques cellules (3 à 5 au plus), est celui d'un tonnelet.

Ce filament unisérié est à l'origine d'un protonéma hétérotriche, constitué d'une partie rampante et d'une partie dressée, tout à fait semblable, en aspect et en dimension, à celui engendré par la germination des tétraspores du *Liagora*

Source MNHN, Paris



Pl. VI — 21 : *L. tetrasporifera*, début de germination d'une carpotétraspore. 22 : *L. tetrasporifera*, début de germination d'une carpotétraspore dont le contenu s'est vidé pour donner naissance au filament germinatif. 23 : *L. tetrasporifera*, carpotétraspore et son filament germinatif. 24 : *L. tetrasporifera*, carpotétraspores et leurs filaments germinatifs. 25 : *L. tetrasporifera*, extrémité d'un filament germinatif de carpotétraspore. La cellule terminale possède une cytologie très différente de celle des autres cellules. 26 : *L. tetrasporifera*, protonéma engendré par la germination d'une carpotétraspore. Seule la partie prostrée est visible ici.

Toutes les échelles sont exprimées en μm.

Source MNHN, Paris

distenta. En effet, le filament initial, après avoir atteint une longueur d'environ dix cellules, se ramifie activement pour donner une lame d'un beau rouge vif (Pl.VI fig. 26). A partir de cette lame prostrée se dressent des filaments unisériés du type *Acrochaetium* (Pl. VII, fig. 27). Les cellules les composant sont allongées et cylindriques (50 μm de long et 12 μm de large). Leur contenu est caractérisé par un plaste plurilobé, pariétal, muni d'un volumineux pyrénoïde à très gros granules de rhodamylon. On a d'ailleurs pu suivre la formation de l'organisation du contenu cellulaire dans les parties apicales de certains filaments et montrer qu'il n'existe qu'un seul plaste par cellule, mais si lobé, au stade adulte, que l'on peut être amené à croire à la présence de plusieurs plastes. Les cellules apicales des filaments ont un contenu non pigmenté et très réfringent, avec de nombreux granules dont la présence atteste l'existence de nombreuses réserves.

C'est sur ces filaments dressés que naissent directement les bourgeons gamétophytiques. Il y a d'abord ramification assez lâche du filament dressé, puis, dans la partie subterminale, quelques cellules sans aucune caractéristique spéciale, bourgeonnent activement sur un même rameau ou sur des ramifications voisines (Pl. VII, fig. 28) du même filament dressé. Ce bourgeonnement engendre de nouveaux filaments dont la première cellule est à l'origine de deux types de rameaux, simultanément : les uns, faits de cellules cylindriques allongées (50 à 60 μm de long et 6 à 7 μm de large), à phototropisme négatif, les autres, faits de cellules en tonnelet (12 μm de long et 8 μm de large), à phototropisme positif. Les premiers sont fort peu pigmentés alors que les autres sont d'un rouge très vif. La première division de la cellule initiale de ces rameaux engendre donc deux types de cellules à potentialités très différentes, les unes destinées à jouer un rôle fixateur, non photosynthétiques, les autres, au contraire, destinées à constituer les axes d'un futur thalle gamétophytique. Il serait intéressant d'étudier la physiologie de ce type de cellule.

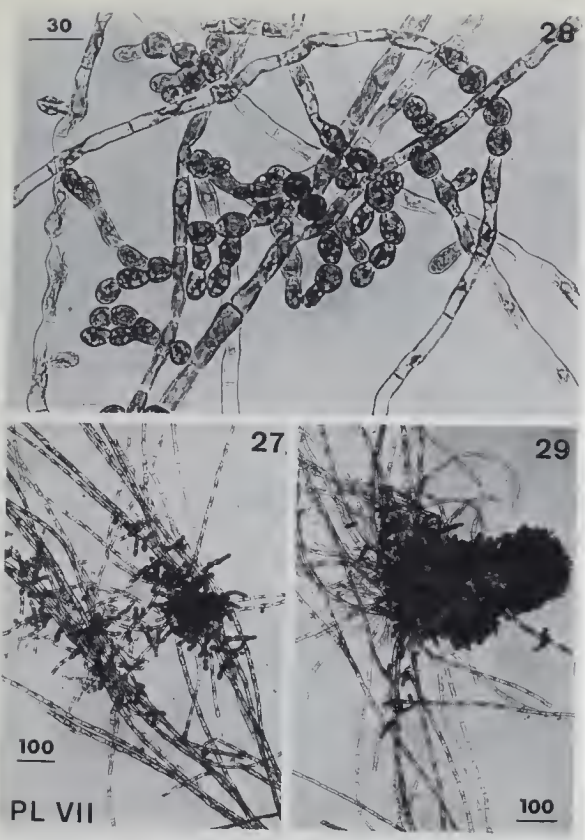
Comme on l'a déjà noté pour le *Liagora distenta*, la formation des jeunes gamétophytes (Pl. VII, fig. 29) est ici aussi très semblable à celle observée par BOILLOT chez l'*Helminthora divaricata* (1971), mais ici la distinction entre les rameaux rhizoïdiens et les rameaux axiaux est beaucoup plus nette.

Ici, comme chez le *Liagora distenta* et le *Liagora farinosa*, le nouvel individu formé est porté par le filament dressé du thalle hétérotriche engendré par la germination de la carpotétraspore. Chez le *Liagora harveyana*, il semble se former directement à la germination de la carpotétraspore mais WOELKERLING (qui a cultivé cette algue, voir ABBOTT, *Yamadaella*, 1970) n'a-t-il pas été abusé par le phénomène décrit page 287.

Le *Liagora tetrasporifera* présente donc une alternance de générations digénétique, les carpotétraspores produisant directement le gamétophyte. WOELKERLING est parvenu, semble-t-il, à la même conclusion avec le *Liagora harveyana* Zeh.

Le *Liagora tetrasporifera*, comme, sans doute, les autres Nemalionales à carpotétraspores, a donc une alternance de générations digénétique, le gamétophyte étant directement produit par les carpotétraspores issues du carpotétrasporo-

Source MNHN, Paris



Pl. VII. — 27 : *L. tetrasporifera*, partie dressée du protonéma né de la germination d'une carpotétraspore, avec début de la formation de bourgeons gamétophytiques. 28 : *L. tetrasporifera*, détail des rameaux engendrant un gamétophyte. 29 : *L. tetrasporifera*, jeune gamétophyte porté par les filaments dressés dont il est issu.

Toutes les échelles sont exprimées en µm.

Source MNHN Paris

phyte (BØRGESEN l'avait très clairement supposé dès 1927). La méiose, selon toute vraisemblance (comme BODARD l'a démontré chez l'*Helminthocladia senegalensis*, 1971), doit s'effectuer lors de la formation des carpotétraspores. Le cycle nucléaire est, par conséquent, haplodiplophasique, avec un raccourcissement de la durée de la diplophase, limitée, en l'absence de tétrasporophyte indépendant, au seul carpotétrasporophyte.

On pourrait dire aussi, avec MAGNE (sous presse), que le *Liagora tetrasporifera* possède une alternance de générations trigénétique : le gamétophyte macroscopique porte les deux autres générations; le carposporophyte représenté par les quelques cellules du gonimoblaste développé à partir du carpogone fécondé in situ, et le tétrasporophyte réduit à la carpospore, le carposporocyste, par la méiose qu'il subit, donnant naissance directement à un tétrasporocyste. Le carpotétrasporophyte contiendrait ainsi les générations carposporophytique et tétrasporophytique condensées. Une évolution régressive importante aurait donc frappé, ici, deux des trois générations fondamentales caractérisant le cycle de toutes les algues rouges (FELDMANN, 1952).

E. EXISTENCE DE MONOSPORES CHEZ LE *LIAGORA DISTENTA*.

Sur le tétrasporophyte de cette espèce, nous avons observé, une fois l'émission des tétraspores effectuée, l'apparition de monosporocystes. Les monospores qui s'en échappent, en germant, redonnent de nouveaux tétrasporophytes. Il s'agit donc, ici, de multiplication végétative. Cette possibilité de donner naissance à des monospores a été notée chez plusieurs autres Nemalionales. C'est ainsi que les tétrasporophytes du *Liagora farinosa* Lamour. (VON STOSCH, 1965), du *Nemalion helminthoides* (Velley) Batters (CHANG, 1962), du *Nemalion pulvinatum* Grünow (UMEZAKI, 1967), du *Nemalion multifidum* (Weber et Nohr) J. Ag. (FRIES, 1967) et du *Pseudogloiophloea confusa* (Setchell) Levring (RAMUS, 1969), sont capables de se reproduire par monospores. Par contre, aucune monospore n'a été observée encore sur les filaments du protonéma gamétophytique. Ceci ne signifie toutefois pas qu'il soit incapable d'en former, mais les conditions nécessaires à l'apparition de celles-ci n'ont sans doute pas été réunies dans nos cultures.

Chez le *Liagora tetrasporifera*, aucune monospore n'a été formée ni émise par le protonéma gamétophytique.

VON STOSCH, de même, a constaté que les monospores ne se sont pas développées sur les gamétophytes du *Liagora farinosa* en culture, mais sur les échantillons qu'il a récoltés aux Iles Lipari, elles semblaient présentes.

IV. DISCUSSION ET CONCLUSION

Avant de conclure sur le cycle du *Liagora tetrasporifera* et sur celui du *Liagora distenta*, il faut apporter une remarque importante concernant les résultats obtenus en culture. Dans la nature, le développement des différentes phases de

Source MNHN, Paris

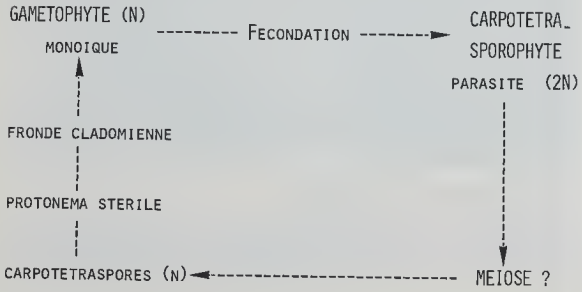
ces algues est lié à de nombreux facteurs externes de leur environnement. Les échantillons cultivés au laboratoire, en milieu artificiel, ne sont pas dans les conditions normales, il faut donc accepter les résultats obtenus avec le maximum de prudence, quand on sait que l'expression phénotypique d'un génotype peut varier selon les conditions extérieures.

Cependant, la découverte, dans la nature du sporophyte du *Nemalion multifidum* par FRIES (1969), sur la côte occidentale de Suède, dont elle avait mis la présence en évidence, en cultivant au laboratoire des fragments de thalles gamétophytiques non fertiles, est une confirmation spectaculaire de l'expérimentation et la preuve que les individus formés en milieu artificiel peuvent être similaires de ceux formés dans les conditions normales.

Il serait donc souhaitable, pour que les présents résultats expérimentaux prennent toute leur valeur, que soient trouvés dans la nature les formes que l'on a vues se développer in vitro. Mais leurs dimensions très réduites et leur ressemblance avec les espèces du genre *Acrochaetium* rendent ce travail difficilement réalisable.

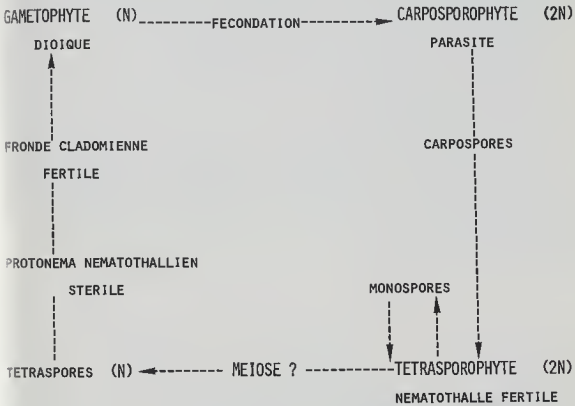
En tenant donc compte des remarques précédentes, on peut résumer les résultats obtenus comme suit :

- le cycle de développement du *Liagora tetrasporifera* présente une alternance de générations digénétique (ou trigénétique selon MAGNE, cf. ci-dessus), les carpotétraspores engendrant directement un protonéma hétérotriche nain, sur les filaments dressés duquel apparaissent de nouveaux gamétophytes. On trouve donc une génération, selon toute vraisemblance diploïde, composée par les filaments gonimoblastiques parasites du gamétophyte parental, et une génération sans doute haploïde, composée par le protonéma hétérotriche et les gamétophytes qu'il engendre. Les observations faites sur le *Liagora harveyana* semblent confirmer ce point de vue, du moins pour ce qu'on en sait par ABBOTT (*Yamadaella*, 1970). Le tableau suivant réunit toutes les données précédentes :



Source MNHN Paris

De son côté, le *Liagora distenta* a un cycle de développement qui présente une alternance de générations trigénétique, comprenant : un gamétophyte macroscopique naissant d'un protonéma hétérotriche, différencié en cladome multiaxial, un carposporophyte parasite sur le gamétophyte parental, morphologiquement très réduit, et un tétrasporophyte nain né de la germination de la carpospore, ressemblant au protonéma du gamétophyte. Son cycle peut donc être défini comme trigénétique hétéromorphe et vraisemblablement haplodiplophasique, les générations diploïdes étant constituées sans doute par les filaments gonimoblastiques ou encore carposporophytiques, et par le tétrasporophyte, tous deux de dimensions réduites, et la génération haploïde constituée par le protonéma nématothallien gamétophytique et la fronde fertile qu'il porte. Ces résultats sont résumés par le tableau suivant :



L'existence d'un tétrasporophyte chez le *Liagora distenta* confirme, avec VON STOSCH (1965), FRIES (1967), UMEZAKI (1967, 1971), BOILLOT (1968) et RAMUS (1969), les assertions de MAGNE à propos des Némalionales et contribue à réfuter l'opinion de SVEDELIUS (1915) et de KYLIN (1916), plaçant la méiose dans le carpogone, immédiatement après la fécondation. La classification des Némalionales selon KYLIN (1956) est donc à modifier.

Ce tétrasporophyte est néoténique; c'est en effet le protonéma né de la carpospore qui devient fertile à ce stade juvénile, alors que le gamétophyte se développe sur un protonéma stérile, issu de la tétraspore.

Source MNHN, Paris

Les tétraspores sont disposées de deux manières dans les tétrasporocystes du *Liagora distenta* : cruciée et tétraédrique. Il en est de même chez le *Liagora farinosa*. Chez le *Pseudogloiophloea confusa*, chez le *Scinaia furcellata* et le *Scinaia japonica*, la disposition des tétraspores peut être, en plus des deux précédentes, zonée et décussée. Le mode de segmentation des tétrasporocystes n'a donc, selon toute vraisemblance, aucune signification taxinomique dans ce groupe.

Le tétrasporophyte du *Liagora distenta*, tout comme celui du *Liagora farinosa*, du *Nemalion multifidum*, du *Nemalion helminthoides*, du *Nemalion pulvinatum* et du *Pseudogloiophloea confusa*, est capable de se reproduire par monospores. Il est donc totalement indépendant du gamétophyte. Ce dernier, au contraire, dépend totalement, pour son existence, du tétrasporophyte, car il ne peut pousser qu'à partir de tétraspores produites dans les tétrasporocystes du tétrasporophyte, et il manque de moyen de multiplication végétative (absence de monospores mentionnée aussi par VON STOSCH chez le gamétophyte du *Liagora farinosa*).

Les conditions d'apparition des tétraspores, des monospores et des bourgeons gamétophytiques restent à préciser. La caryologie de ces deux espèces demeure aussi une inconnue actuellement et doit être approfondie pour confirmer la localisation présumée de la méiose, au moment de la formation des carpotétraspores chez le *Liagora tetrasporifera*, et des tétraspores chez le *Liagora distenta*.

Enfin, l'organisation des axes de la zone centrale des thalles gamétophytiques, à partir des bourgeons primordiaux, et, surtout, la différenciation des frondes gamétophytiques multiaxiales dérivant d'une cellule unique, soit tétraspore pour le *Liagora distenta*, soit carpotétraspore pour le *Liagora tetrasporifera*, sont deux problèmes qui demeurent entiers.

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THE PRESENCE OF TETRASPORANGIA AND CARPOSPOROPHYTES ON THE SAME THALLUS IN PTEROSIPHONIA THUYOIDES

H. M. PARKES *

SUMMARY. — The simultaneous occurence of tetrasporangia and carposporophytes in *Pterosiphonia thuyoides* (Harv. in Mackay) Schm. is recorded from Ireland.

RÉSUMÉ. — La présence simultanée des tétrasporanges et des carposporophytes de *Pterosiphonia thuyoides* (Harv. *in* Mackay) Schm. est signalée en Irlande.

While carrying out observations on species of *Pterosiphonia* to be found on the coast of county Dublin a specimen of *Pterosiphonia thuyoides* (Harv. in Mackay) Schm. bearing tetrasporangia and carposporophytes was collected at Sandycove (Irish National Grid 0 26 28) in september 1960.

The specimen was normal in appearance as were the fruiting bodies. The tetrasporangia, which were carried on the ultimate branches of the thallus, were numerous and many were mature. At the base of these fertile branches four carposporophytes were found, one containing fully developed carpospores.

Unfortunately this specimen was preserved before these facts were observed so that it was not possible to carry out any culture studies.

At Sandycove, where *P. thuyoides* is found growing in pools in the lower littoral, phenological observations of this species were kept during a three year period. These indicated that the main fruiting season for both types of sporangia is summer and autumn and that tetrasporic plants predominate. No other «abnormalities» were found.

The occurence of tetrasporangia and sexual organs on the same thallus among the species of Rhodophyceae is an established fact and has been discussed by various authors (DIXON 1961; DREW 1951, 1955; FRITSCH 1945; LAWSON & RUSSELL 1967). In the case of the genus *Pterosiphonia* the phenomenon has

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Rev. Algol., N. S., 1976, XI, 3-4 : 299-301.

Source MNHN, Paris

only been recorded in one of the species, *P. parasitica* (Huds.) Falkenb., by LODGE (1945/7) and SUNESON (1940). There do not appear to be any published records for such occurences in *P. thuyoides*.

The Sandycove material has been deposited in the herbarium of the Botany Department of University College, Galway.

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Source MNHN, Paris

Fig. 1. – Part of frond of *Pterosiphonia thuyoides* bearing tetrasporangia and carposporophytes. x 22; Fig. 2. – Enlargement from fig. 1 of a carposporophyte with carpospores. x 100; Fig. 3. – Enlargement from fig. 1 of a mature tetrasporangium. x 400. Photographs by Mr P. Cooke.

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THE MARINE ALGAE OF IVORY COAST AND CAPE PALMAS IN LIBERIA (GULF OF GUINEA)

David M. JOHN *

SUMMARY. — This annotated list of marine algae from Ivory Coast and Liberia recognises 103 separate entities of which 95 have been identified to species. Over a third of the algae are reported for the first time from these two countries. Information on the ecology, reproductive status, local distribution in the Gulf of Guinea, details of collection and features of special taxonomic interest, are included for each of the separate entities.

INTRODUCTION

The first general account of the littoral ecology of the rocky shores of Ivory Coast and also Cape Palmas in Liberia has only recently been published (JOHN 1972). Sporadic collecting of marine algae has taken place in these two countries prior to this ecological work but only a few of these have been reported in the rather scattered literature relating to West Africa. Mostly single records are given for Ivory Coast in publications by AMOSSE (1970), BODARD (1966a, 1966b), LAWSON and PRICE (1969), POST (1963, 1966a, 1966b) and for Liberia by ASKENASY (1888, p. 39) also cited in FOX (1957).

A large proportion of the marine algae mentioned in this paper were collected during a short visit to these two countries made between december 1971 and january 1972. Various other collections have also been located and these specimens are also included.

SYSTEMATIC LIST

In this annotated list the genera are arranged alphabetically within the major groups and the species in their respectiv genera are also in alphabetical order. Included under each species is information on its ecology, geographical distribution in the Gulf of Guinea, presence and type of reproductive organs, as well as any points of special taxonomic interest. The terminology of LEWIS (1961) is used when referring to the position of a plant on the shore whilst the four

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Rev. Algol., N. S., 1976, XI, 3-4 : 303-324.

Source MNHN, Paris

categories of exposure to wave action are used in a similar sense to those given by LAWSON (1956). The place names of the collecting localities are taken from MICHELIN map number 175 and are shown in figure 1. All the collections of plants from Sassandra were made about 6 km to the west of the town at Batélébré whilst the Canal de Vridi is just a few kilometres from the center of Abidjan.

The largest number of specimens were collected by Mr. F. O. K. SEKU and myself and for convenience our names are abbreviated as J & S. Examined also were herbarium sheets of algae collected by Professor R. SOURIE (S) from Ivory Coast and now deposited in the herbarium of Professor J. FELDMANN in Paris. Another collection studied was one of dried material sent to us from the «Centre O.R.S.T.O.M. d'Adiopodoumé» in Abidjan. Many of these sheets have more than one collecting number and so each has also been given a new number (6500 - 7500) when it has been incorporated into the phycological section of the herbarium in the Botany Department, University of Ghana, Legon (GC). These specimens were collected by the following persons whose names have been abbreviated by the letters shown in brackets : Y. ATTIMS (A), F. BERNARD (B), G. CREMERS (C), F. HALLE (H), C. HUTTEL (Hu) and P. DE RAHMS (R). Finally some collections in spirit were kindly given to us by the «Département de Biologie, Université d'Abidjan», and were without the names of the collectors. Whenever possible the number of each collection of a species is given along with the name of the collector or collectors, the date and the locality it came from. All plants marked with an asterisk are species reported from this part of the Guinea Coast for the first time.

The majority of the plants mentioned in this paper are deposited in the herbarium at the Botany Department of the University of Ghana, Legon whilst over forty sheets are in Professor J. FELDAMNN's herbarium in Paris. A number of duplicates are also lodged in the cryptogamic herbarium at the British Museum (Natural History), London.

CHLOROPHYTA

Bryopsis pennata Lamouroux

Occuring as soft and flaccid plants forming large patches particularly in moderately wave-sheltered tidepools and on horizontal rock surfaces in the lower eulittoral subzone.

Found at Cape Palmas (J & S., 6963, 6995, 2.1.72) in Liberia and Sassandra (J & S., 6867, 30.12.71) and Fresco (S. 490, 491, 2-6.2.54) in Ivory Coast. This plant has previously been reported in the Gulf of Guinea from Cameroun, Dahomey, Ghana, Nigeria, Togo and the offshore island of Sao Tomé.

* *Caulerpa taxifolia* (Vahl) C. Agardh

Collected at Fresco (S., 2-6.2.54) in Ivory Coast by Pr. R. SOURIE but without a number and with no accompanying ecological information. This

Source MNHN Paris

plant is reported in the Gulf also from Ghana, Sao Tomé and with doubt from Principe.

Chaetomorpha antennina (Bory) Kützing

As coarse and hair-like tufts growing in the upper part of the lower eulittoral subzone on moderately wave-exposed rocks.

Collected at Cape Palmas (J & S., 6943, 6954, 2.1.72), Tabou (J & S., 6908, 1.1.72), Grand Bassam (7027, 17.11.61), Sassandra (A., 10, 6552, 12.12.66; J & S., 6853, 30.1.72) and from Fresco (S., 2-6.2.54), known also from Cameroun, Ghana, Nigeria and Sao Tomé in the Gulf.

Chaetomorpha linum (O. F. Müller) Kützing

Found as a few filaments mixed in with other small algae growing in moderately wave-sheltered situations in the eulittoral zone.

Gathered at Cape Palmas (J & S., 6995, 2.1.72) and Sassandra (J & S., 6927, 30.12.71) being also reported in the Gulf of Guinea from Cameroun, Ghana (as *Chaetomorpha area*) and Togo.

* *Chaetomorpha nodosa* Kützing

A few filaments found in amongst *Cladophora* plants collected at Grand Lahou (C & H., 565, 7031, 12.2.67) and from a jetty in the Canal de Vridi near Abidjan (S., 504, 27.1.54). Reported previously in the Gulf from Cameroun and Togo.

* *Cladophora albida* (Hudson) Kützing

Plants either growing as dense spongy tufts on the floor of shaded tidepools in the littoral fringe or as larger looser tufts or mats in the lower part of the eulittoral zone on wavecut platforms and especially abundant in brackish-water.

Found at Cape Palmas (J & S., 6954, 6969, 2.1.72) and with some doubt from Grand Lahou (C & H., 563 to 565, 6575 to 6578, 12.2.67), Fresco (A & C., 20, 683, 6573, 12.7.67; S., 524, 2-6.2.54) and the Canal de Vridi (S. 504, 27.1.54). It has previously been reported along the Guinea Coast from Cameroun, Ghana, Nigeria and Togo.

Cladophora prolifera (Roth) Kützing

Growing as dark green and coarse cushion-like tufts on rocks and lithothamnia in moderately sheltered to moderately wave-exposed situations in the lower eulittoral subzone.

Collections from Cape Palmas (J & S., 6944, 6997, 2.1.72), Tabou (J & S., 6906, 7009, 1.1.72), Sassandra (J & S., 6850, 30.12.71) and Fresco (S., 511, 2.-6.2.54) being previously reported in the Gulf from Ghana (as *Cladophora trichotoma*), Sao Tomé and with doubt from Cameroun and Gabon.

Source MNHN, Paris

* *Cladophora vagabunda* (Linnaeus) Van den Hoek

Occuring in amongst other algae usually growing on moderately wave-sheltered beach rocks in the lower part of the eulittoral zone.

Gathered at Sassandra (J & S., 6982, 30.12.71) and Fresco (S., 499, 512, 522, 2-6.2.54) and also known from Ghana (as *Cladophora fascicularis*), Nigeria (as *C. fascicularis*) and Togo.

* *Codium guineense* Silva

Forming bushy clumps in some abundance especially in wave-sheltered tidepools in the lower part of the eulittoral zone.

Found at Sassandra (J & S., 6879, 30.12.71) and Tabou (J & S., gametangia - 6898, 1.1.72) in Ivory Coast.

This plant appears to be common in various places along the West African coast but has not as yet been validly published. For comments regarding the status of this species refer to LAWSON and PRICE (1969).

* *Enteromorpha clathrata* (Roth) Greville

Collections of this plant have been made in Ivory Coast at Fresco (A & C., 167, 679, 6736, 12.7.67) and Grand Lahou (C & H., 566, 6572, 12.2.67) and it is also known in the Gulf from Cameroun (unpublished), Ghana, Nigeria, Sao Tomé and Togo.

Enteromorpha flexuosa (Wulfen *ex* Roth) J. Agardh
Subspecies *flexuosa* J. Agardh

Growing in brackish-water conditions often mixed with *Cladophora*, or on moderately wave-sheltered beach rocks in the upper eulittoral subzone; occasionally as low mats on stranded logs and then in the littoral fringe.

Gathered at Sassandra (J & S., 6983, 6987, 29.12.71), Grand Bassam (7027, 17.11.61), Canal de Vridi (S., 506, 504, 27.1.54) and a few fragments found in a collection from Cape Palmas (J & S., 6964, 2.1.72). This species has also been reported in the Gulf from Cameroun (as *Enteromorpha compressa*), Ghana, Nigeria, Sao Tomé and Togo.

Rhizoclonium africanum Kützing

Filaments usually entangled with small red algae growing in cracks, crevices or beneath rock overhangs, or on the underside of logs in the littoral fringe and especially in brackish-water situations.

Collections made at Tabou (J & S., 6979, 6890, 6981, 1.1.72), Sassandra (J & S., 6988, 29.12.71) and also on mangroves at Azuretti (A, C & H., 567, 6563, 14.2.67) which is near to Grand Bassam. Known in the Gulf of Guinea from Cameroun (unpublished) and Ghana (as *Rhizoclonium hookeri*).

* *Rhizoclonium riparium* (Roth) Harvey

Occurring on «Plateforme d'abrasion au niveau de la basse mer de vive eau» at Fresco (S., 524, 2-6.2.54) according to the label on the specimen. Found in the Gulf also in Cameroun, Ghana and Togo.

Source MNHN Paris

* *Siphonocladus brachyartus* Svedelius ?

Growing as dense, spongy, cushion-like tufts or as a springy «turf» on nearly horizontal rocks in the eulittoral zone and extending into the littoral fringe beneath rock overhangs and in shaded tidepools at the entrance to the Tabou River (J & S., 6894, 1.1.72).

This plant was originally reported to be a *Valoniopsis* (JOHN 1972) but on further consideration it seems to be closely related to *Siphonocladus brachyartus* described by SVEDELIUS (1895) from the Magellan Straits in South America. It resembles this species in the dimensions of the cells of the branches and the branching pattern. In both plants longitudinal division in the branches is very rare and there are often cross-walls associated with the side branches. In fact, the only important difference between this genus and *Valoniopsis* is in the form and development of the branching which in the case of the latter genus is fully described and illustrated by BØRGESEN (1934). The Ivorian and South American plants are very similar not only in form but are found in similar habitats, nevertheless, the identification of the West African material is still considered with some doubt. The main reason for this doubt is the wide disparity in climate between the two regions with the Magellan Straits having arctic-boreal conditions. Unfortunately attempts to trace the type material of *Siphonocladus brachyartus* have so far been unsuccessful; correspondence with the curator of the Uppsala Museum (UPS) has revealed the possibility that the collection might have been lost.

Struvea anastomosans (Harvey) Piccone et Grunow

Occuring as semi-prostrate clumps in the «algal turf» growing on moderately wave-sheltered rocks in the lower eulittoral subzone.

Found at Sassandra (J & S., 6924, 30.12.71) and Fresco (S., 519, 2-6.2.54) in Ivory Coast and previously reported in the Gulf of Guinea from Cameroun, Gabon, Ghana and Sao Tomé.

Ulva fasciata Delile

Occuring most commonly in moderately sheltered to moderately wave-exposed tidepools in the lower eulittoral subzone.

Collections from Cape Palmas (J & S., 6996, 6945, 2.1.72) and Grand Bassam (7012, 17.11.63) in Ivory Coast and previously known from Ghana and Sao Tomé.

Ulva lactuca Linnaeus

As dense mats growing over logs in the littoral fringe being associated with a good deal of sand or as small solitary plants on larger algae in the «turf» found in the lower eulittoral subzone.

Gathered at Cape Palmas (J & S., 6999, 2.1.71, 6849, 30.12.71) whilst recorded also from Dahomey, Ghana, Principe, Sao Tomé and Togo.

* *Ulva rigida* C. Agardh

Growing on logs in the littoral fringe at Sassandra (J & S., 6875, 30.12.71; A., 13, 6534, 12.12.66) and Fresco (S., 2-6.2.54) and known previously in the Gulf of Guinea only from Ghana.

Source MNHN, Paris

PHAEOPHYTA

Bachelotia antillarum (Grunow) Gerloff

Forming small soft tufts or more usually as extensive mats growing on moderately wave-sheltered rocks in the upper eulittoral subzone, often associated with a good deal of sand when found on beach rocks.

Collected at Cape Palmas (J & S., plurilocular sporangia - 6937, 2.1.72) and Sassandra (J & S., 6923, 6927, 30.12.72) and also reported from Ghana, Nigeria and Sao Tomé.

* *Basispora africana* John et Lawson

As black and often very slippery expansions over moderately sheltered to moderately wave-exposed rocks, sometimes in the form of coalescing rings, growing just above the lithothamnia subzone.

Collected at Sassandra (J & S., unilocular sporangia - 6860, 2.1.72), Tabou (J & S., unilocular sporangia - 6929, 1.1.72) and Cape Palmas (J & S., 6932, unilocular sporangia - 6873, 2.1.72).

Chnoospora minima (Hering) Papenfuss

Growing as coarse clumps in the lower part of the upper eulittoral subzone on moderately wave-exposed rocks.

Found at Cape Palmas (J & S., 6938, 2.1.72) and Fresco (A & C., plurilocular sporangia - 24, - 687, 6565, 12.7.67) whilst also known from Dahomey, Ghana, Nigeria, Sao Tomé and Togo.

Colpomenia sinuosa (Roth) Derbès et Solier

Plants to about 2 cm across and growing on larger algae in moderately wave-sheltered situations in the lower subzone of the eulittoral.

Gathered only from Sassandra (J & S., 6881, 30.12.71) in Ivory Coast and elsewhere in the Gulf known from Ghana, Togo and Sao Tomé.

Dictyopteris delicatula Lamouroux

Occuring as dense low mats on moderately wave-sheltered rocks and forming small and compact clumps in more wave-exposed situations in the sublittoral fringe and in tidepools at higher levels on the shore.

Collected at Cape Palmas (J & S., 6939, 2.1.72) and Sassandra (A., 1, 6551, 12.12.66; J. & S., 6858, 30.12.71, 6990, 29.12.71) and in other parts of the Gulf of Guinea known from Ghana and Nigeria.

* *Dictyota bartayresii* Lamouroux

A few small plants found growing in moderately wave-sheltered tidepools.

Found only at Cape Palmas (J & S., 6953, 2.1.72) in Liberia and also reported from Cameroun, Ghana, Principe and Sao Tomé.

Source MNHN, Paris

* *Dictyota cervicornis* Kützing
Form *curvula* Taylor

Found on «rochers de Tabou» (B, C, Hu & R., 583, 6557, ?.2.67) in Ivory Coast and unpublished records for this plant exist for both Ghana and Sao Tomé.

Dictyota ciliolata Kützing

Growing as bushy clumps on moderately wave-sheltered rocks in tidepools in the lower eulittoral subzone.

Collections from Sassandra (J & S., oogonia and sporangia - 6885, - 6889, 31.12.71) and Tabou (B, C, Hu & R., 583, 6559, sporangia - 585, 6561, ?.2.67) being known also in the Gulf from Ghana, Nigeria and Sao Tomé.

All Ivory Coast plants were somewhat unusual in having wide concentric bands of alternating lighter and darker brown on dried specimens with the darker ones being irridescent in freshly collected material.

* *Dictyota dichotoma* (Hudson) Lamouroux ?

A few small and immature plants found growing on wave-cut platforms or as an epiphyte on a species of *Laurencia* in a moderately wave-sheltered tidepool.

Found at Sassandra (J & S., 6973, 30.12.71) and Fresco (S., 517, 518, 2-6. 2.54) and known from Sao Tomé and Principe and with doubt from Ghana (unpublished) and Togo.

This record is given here with some reservation as the possibility does exist that these plants from Ivory Coast are just immature forms of some of the other *Dictyota* species mentioned above.

Ectocarpus breviarticulatus J. Agardh

As rope-like tufts on rocks and occasionally as an epiphyte on *Chnoospora* growing on moderately wave-exposed rocks in the upper eulittoral subzone.

Collected at Cape Palmas (J & S., plurilocular sporangia - 6940, - 6938, 2.1.72) Monogaga (C., 531, 6568, 1.1.76) and Fresco (A. & C., 22: 685, 6566, 12.7.67) being reported in the Gulf also from Dahomey, Ghana, Nigeria and Togo.

* *Ectocarpus rhodochortonoides* Börgesen

Growing on *Gracilaria dentata* in the lower eulittoral subzone on moderately wave-exposed rocks.

Gathered near Sassandra (J & S., plurilocular sporangia - 6991, 29.12.71) in Ivory Coast and also known from Ghana.

* *Giffordia rallsiae* (Vickers) Taylor

Forming small globose tufts on rocks and *Siphonaria* shells in moderatly wave-exposed situations in the upper part of the eulittoral zone.

Found at Cape Palmas (J & S., plurilocular sporangia - 7005, 2.1.72) in Libe-

Source MNHN, Paris

ria and also reported in the Gulf of Guinea from Dahomey, Ghana and Togo.

Giffordia sp.

A few sterile plants in which the chloroplasts were contracted or occasionally discernable as a number of discs have been collected at Fresco (A & C., 20, 683, 6573, 12.7.67).

Lobophora variegata (Lamouroux) Womersley

The prostrate form of this species has been found growing in moderately wave-exposed tidepools in the eulittoral zone.

A single collection from Cape Palmas (J & S., 6960, 2.1.72) and previously recorded in the Gulf of Guinea as *Pocockiella variegata* from Principe, Cameroun and Ghana.

* *Padina australis* Hauck ?

A few small plants collected from «Plateforme d'abrasion au niveau de la basse mer de vive eau, peu abondant.» at Fresco (S., sporangia - 520, 2-6.2.54) in Ivory Coast and also known from Cameroun (as *Padina gymnospora*).

This determination must be regarded with some doubt since the plants are small and rather fragmented though the thickness of the thallus does vary from two cells at the margin to four below and the hair zones are very indistinct.

Padina tetrastromatica Hauck

Growing as small patches on moderately wave-sheltered rocks in the lower eulittoral subzone and often abundant and as large plants when in shallow tidepools.

Gathered at Sassandra (J & S., 6878, 30.12.71) and Tabou (J & S., 6903, 1.1.72) and in the Gulf also known from Ghana and Togo.

Padina vickersiae Hoyt

Occuring as variously sized patches on moderately wave-sheltered rocks in the lower eulittoral tidepools and usually associated with *Sargassum*.

Collections from Cape Palmas (J. & S., 6904, 6947, 2.1.72), Tabou (B, C, Hu & R., 581, 6570, ?.2.67) and near Sassandra (J & S., sporangia - 6880, 30. 12.71) and also known in the Gulf from Cameroun, Sao Tomé and Principe.

Ralfsia expansa (J. Agardh) J. Agardh

As crusts covering moderately sheltered to moderately wave-exposed rocks in the lower eulittoral subzone and at higher levels in rocky tidepools.

Found at Cape Palmas (J & S., 6962, 2.1.72) and Sassandra (J & S., 6873, 6859, 30.1.71) and reported also from Cameroun, Dahomey, Ghana and Togo.

Sargassum vulgare C. Agardh

Occuring in abundance in shallow rocky tidepools and present on open rocks

Source MNHN, Paris

except where wave action is severe, usually defines the upper limit of the sublittoral fringe.

Found at Cape Palmas (J & S., 6948, 2.1.72) and Sassandra (J & S., 6857, 6948, 30.12.71; A., 8, 6538, 12.12.66) and known from all countries bordering the Gulf of Guinea from which collections have been made.

* *Sphacelaria furcigera* Kützing

It has only been found as propagules trapped in the «algal turf» collected from Cape Palmas (J & S., 7006, 2.1.72) and Sassandra (J & S., 6888, 30.12.71) and previously reported from Dahomey, Ghana and Cameroun.

Sphacelaria tribuloides Meneghini

Forming small cushion-like tufts on moderately wave-exposed rocks and *Siphonaria* shells in the upper eulittoral subzone.

Collected at Cape Palmas (J & S., propagules - 6958, - 7004, 2.1.72) and also known in the Gulf from Ghana and Togo.

RHODOPHYTA

Amphiroa beauvoisii Lamouroux

Growing on moderately wave-exposed rocks in the lower eulittoral subzone.

Collected in Ivory Coast only from Sassandra (J & S., 6864, 30.12.71) and recently also reported from Ghana.

Amphiroa peruana Areschoug

Forming semi-prostrate clumps in the lower eulittoral subzone on moderatly sheltered to moderatly wave-exposed rocks.

Found at Sassandra (J & S., 6884, 30.12.71) and Cape Palmas (J & S., 6773, 2.1.72) and previously reported from Ghana.

* *Audouinella dasyae* (Collins) Woelkerling

As a fine felty layer over the foliar appendages of *Sargassum vulgare* growing in moderately wave-sheltered tidepools in the eulittoral zone.

Found in a collection from Cape Palmas (J & S., monosporangia - 6948, 2.1.72) and known also from Ghana.

* *Audouinella daviesii* (Dillwyn) Woelkerling

Occuring as tufts to about 1 mm in height on the upper parts of the filaments of *Chaetomorpha antennina* growing on moderately wave-exposed rocks.

Plants bearing monosporangia found on *Chaetomorpha* collected at three localities - Cape Palmas (J & S., 6943, 2.1.72), Tabou (J & S., 6908, 1.1.72) and Grand Bassam (7027, 17.11.63). This is the first report of this plant from the Guinea Coast though in West Africa it is also known from the Canary Islands.

Source MNHN, Paris

Bostrychia calliptera Montagne

Growing on moderately wave-sheltered rocks together with other small red algae such as *Caloglossa* in the littoral fringe at the entrance to the Tabou River.

Collected at Tabou (J & S., 6890, 1.1.72) having previously been recorded in the Gulf of Guinea from Ghana.

Bostrychia radicans Montagne
Form *hapteromanica* Post

Found together with other species of red algae growing in the littoral fringe at the entrance to the Tabou River.

This form, only collected at Tabou (J & S., 6890, 6893, 6891, 1.1.72) in Ivory Coast, has previously been reported from Cameroun though the species is also known in the Gulf from Cameroun, Ghana, Nigeria and Sao Tomé.

Bryocladia thyrsigera (J. Agardh) Schmitz

Occuring most commonly as loose mats growing on moderately sheltered to moderately wave-exposed beach rocks which are gently sloping and sand-scoured, occasionally mixed with the «algal turf» in the lower part of the eulittoral zone.

Found at Cape Palmas (J & S., 6935, 2.1.72), Sassandra (J & S., tetrasporangia - 6975, 30.12.71), Tabou (J & S., 6909, 1.1.72) and Fresco (A & C., 15, 678, 12.7.67, tetrasporangia and cystocarps - 6558, 12.7.67; S., 478, 2-6.2.54) in Ivory Coast having previously been recorded in the Gulf from Ghana, Nigeria and Togo.

**Callithamniella tingitana* (Schousboe *ex* Bornet) Feldmann-Mazoyer

Growing as a few sterile filaments mixed with a fine *Polysiphonia* on the floor of a moderately wave-sheltered tidepool in the upper eulittoral subzone.

Gathered at Cape Palmas (J & S., 6961, 2.1.72) in Liberia and also found in Ghana (unpublished).

* *Callithamnion* sp.

A plant believed to be referable to this genus was found as an epiphyte on *Gracilaria dentata* growing in sheltered situations on rocks in the lower part of the eulittoral zone.

Found at Tabou (J & S., 7007, tetrasporangia - 7008, 1.1.72) in Ivory Coast whilst no published records exist for this genus in the Gulf of Guinea.

Caloglossa leprieurii (Montagne) J. Agardh

Occuring as semi-prostrate clumps in cracks, crevices and beneath rock overhangs in the littoral fringe, and in the «turf» of green algae in the eulittoral zone within the entrance of the Tabou River.

Collected only at Tabou (J & S., 6880, 6889, tetrasporangia - 6981, 1.1.72)

Source MNHN Paris

in Ivory Coast and known previously in the Gulf from Cameroun, Ghana and Nigeria.

Caloglossa ogasawaraensis Okamura

Found in the same situations as *Caloglossa leprieurii* in the entrance to the Tabou River (J & S., 6981, 1.1.72) and also reported in the Gulf from the offshore island of Sao Tomé.

Catenella impudica (Montagne) J. Agardh

On wave-sheltered rocks in the littoral fringe at the entrance to the Tabou River (J & S., 6890, 6981, 1.1.72) and known also from Cameroun in the Gulf.

Centroceras clavulatum (C. Agardh) Montagne

A common alga at most localities either growing in the «algal turf» on moderately wave-exposed rocks or as small and often bleached tufts in the upper eulittoral subzone in more wave-exposed situations.

Collected at Tabou (B, C, Hu & R., 587, 6562, ?.2.67; J & S., 6910, 1.1.72), Fresco (A & C., 17, 680, 6567, 12.7.67; S., 514, tetrasporangia - 494, 2-6.2.54) and Sassandra (A., 2, 6550, tetrasporangia - 3, 6539, 12.12.66; J & S., 6845, 30.12.71) in Ivory Coast and Cape Palmas (J & S., 6941, tetrasporangia - 6968, 2.1.72) in Liberia. Occurs in other parts of the Gulf of Guinea in Ghana, Nigeria, Cameroun, Togo, Dahomey and the offshore island of Sao Tomé.

* *Ceramium ledermanni* Pilger

Growing on larger algae in moderately sheltered to moderately wave-exposed situations.

Found at Cape Palmas (J & S., on *Grateloupia doryphora*, carposporangia and tetrasporangia - 6980, - 6955, 2.1.72) and Tabou (J & S., on *Gracilaria dentata*, tetrasporangia - 7008, 1.1.72) and previously only known in the Gulf from Cameroun from where it was first described.

* *Ceramium tenuissimum* (Roth) J. Agardh

According to the label accompanying the specimens collected from Fresco (S., tetrasporangia - 513, - 514, - 515, 2-6.2.54) it was found on «Plateforme d'abrasion au niveau de la basse mer de vive eau.». This species has previously been only reported in the Gulf of Guinea from Cameroun.

Ceramium sp.

A few small fragments of a plant belonging to this genus were found together with filaments of *Platysiphonia* growing in a moderately wave-sheltered tidepool at Tabou (J & S., tetrasporangia - 6914, 1.1.72). The fragments were insufficient to make possible a positive determination.

Source MNHN Paris

* *Champia parvula* (C. Agardh) Harvey

A single collection made at Fresco (S., tetrasporangia - 513, 2-6.2.54) growing in the same situation as *Ceramium tenuissimum*. Reported in the Gulf also from Cameroun and the islands of Sao Tomé and Principe.

Corallina pilulifera Postels et Ruprect

Occuring as large clumps or occasionally as extensive mats growing over the lithothamnia subzone of the eulittoral, particularly abundant on gently sloping surfaces subject to current or wave surge and in the overflow channels of tidepools.

Found at Sassandra (J & S., 6846, 6907, 30.12.71) and Cape Palmas (J & S., 6772, 2.1.72) and having previously been reported from Ghana.

Cryptonemia luxurians (C. Agardh) J. Agardh

Growing usually in moderately wave-sheltered tidepools in the lower part of the eulittoral zone.

Collected at Sassandra (J & S., 6921, 30.12.71) and Fresco (S., 477, 2-6.2.54) and also reported from Ghana as *Cryptonemia seminervis*.

This species and *Cryptonemia seminervis* are very closely related with both having a partial midrib present but *C. luxurians* has the tetrasporangial sori confined to marginal «leaflets» and not scattered over the frond. This distinction between these two species is a doubtful one and it remains to be seen whether these plants are really not conspecific.

* *Erythrocladia irregularis* Rosenvinge

Forming minute discs on the surface of larger algae growing in moderately wave-exposed situations in the eulittoral zone as well as in tidepools and brackish-water habitats.

Occurs at Cape Palmas on *Sargassum* (J & S., 6948, 2.1.72),*Chnoospora* (J & S., 6968, 2.1.72), *Laurencia intermedia* (J & S., 6968, 2.1.72) and *Chaetomorpha antennina* (J & S., 6943, 2.1.72), also on this latter species at Tabou (J & S., 6908, 1.1.72) and Grand Bassam (7027, 17.11.61) whilst at Fresco found on *Struvea anastomosans* (S., 519, 2-6.2.54) and *Rhizoclonium riparium* (S., 524, 2-6.2.54). In other parts it has been reported as *Erythrocladia subintegra* from Ghana and Nigeria.

* *Erythrotrichia carnea* (Dillwyn) J. Agardh

Occuring as solitary plants on larger algae growing in moderately wave-sheltered tidepools in the lower eulittoral subzone.

Collected at Cape Palmas growing on *Laurencia tenera* (J & S., 6951, 2.1.72) and *Padina vickersiae* (J & S., 6947, 2.1.72) and recorded in the Gulf also from Dahomey, Ghana and Togo.

Source MNHN Paris

Galaxaura marginata (Ellis et Solander) Lamouroux

As solitary individuals occuring on moderately wave-sheltered rocks, especially abundant in lower eulittoral tidepools.

Collections obtained from Sassandra (J & S., 6983, 6932, 30.12.71) and Tabou (B, C., 586, Hu & R., 6560, ?.2.67; J & S., 6902, 1.1.72) and also known from Cameroun, Gabon (as *Brachytrichia australis*) and the islands of Sao Tomé and Principe.

* *Galaxaura oblongata* (Ellis et Solander) Lamouroux

Growing in some abundance in the lower part of the eulittoral on moderately-sheltered rocks, often found in tidepools.

Plants found at Tabou (J & S., 6900, 1.1.72) and Fresco (S., cystocarps - 487, 2-6.2.54) and known in the Gulf also from Gabon (as *Galaxaura fragilis*), Sao Tomé (as *Galaxaura cylindrica*), Ghana and Principe.

Galaxaura rugosa (Ellis et Solander) Lamouroux

According to the label accompanying the specimen it was collected on «rochers de Tabou» (B, C, Hu & R., cystocarps - 584, 6534, ?.2.67); this plant has previously been reported in the Gulf from both Cameroun and Sao Tomé.

* *Gelidiopsis variabilis* (J. Agardh) Schmitz

Occuring in moderately sheltered to moderately wave-exposed situations as coarse and erect clumps growing in the upper part of the lithothamnia subzone, especially abundant in tidepools.

Found at Tabou (J & S., 6901, 1.1.72) and Sassandra (J & S., 6887, 30.12.71) in Ivory Coast and also known from Ghana, Cameroun and Sao Tomé.

Gelidium corneum (Hudson) Lamouroux

As bushy clumps in the lower eulittoral subzone on moderately wave-exposed at Cape Palmas (J & S., 7003, tetrasporangia - 6998, 2.1.72) and has previously been reported from Liberia as *Gelidium arbuscula*. It has previously been reported in the Gulf of Guinea from Togo (as *Gelidium arbuscula*), Nigeria (as *Gelidium pusillum*) and is known from Ghana (unpublished).

There is some confusion regarding the typification of this species since the original description of this plant was based on material now known to be referable to *Gelidium sesquipedale* (DIXON, 1967).

* *Gelidium elminense* Dickinson

According to the label with this specimen from Fresco (S., tetrasporangia - 482, 2-6.2.54) it was found at «Niveau inférieur des marées, abondant.» and the only previous report of this plant from the Gulf is from the type locality at Elmina, Ghana.

This plant has the main axes terete except for near the branch tips whilst branches often arise opposite to one another and give the uppermost branches a

Source MNHN Paris

trifid appearance. This species might be regarded as falling into the *Gelidium crinale* complex as defined by DIXON (1958, 1966) in his revision of the European representatives of this genus.

Gelidium pusillum (Stackhouse) Le Jolis

Plants readily referable to this species usually occuring as low ring-like patches growing on moderately sheltered to moderately wave-exposed rocks and lithothamnia in the lower eulittoral subzone. Larger plants from 1 - 2 cm in height and forming dense cushion-like tufts or mats on moderately wave-sheltered granite boulders may be considered to be a variety of this species.

This species (J & S., 6933, 2.1.71) and the variety *pulvinatum* (C. Agarth) J. Feldmann (J & S., 6949, 7030, 2.1.71) were found at Cape Palmas in Liberia.

The variety bears a close resemblance to *Gelidium foliosum* described by DANGEARD (1951) from Sénégal. He points out the close relationship between his new plant and *Gelidium pusillum* var. *pulvinatum* stating it to be «...plus développé plus luxuriant.» *Gelidium reptans*, which has been reported from Sao Tomé, was considered by BØRGESEN (1943) to be referable to this variety of *Gelidium pusillum* though it had earlier been given specific rank by KYLIN (1938). It seems unwarranted at the present time to afford specific rank to plants if there is any doubt regarding their specific status until a global re-appraisal has been made of this extremely polymorphic genus. The species has been reported in the Gulf of Guinea also from Cameroun, Dahomey, Togo, Ghana (unpublished) as well as from Sao Tomé (as *Gelidium reptans*).

Gracilaria dentata J. Agardh

Forming extensive patches on moderately wave-sheltered rocks and as smaller clumps in more wave-exposed situations, usually found in the lower eulittoral subzone and very abundant in large tidepools.

Found at Cape Palmas (J & S., cystocarps - 6936, 2.1.72), Sassandra (J & S., 6919, 30.12.71; A., cystocarps - 9, 6542, 12.12.66; cystocarps - 7025, 12.4.60) and Fresco (S., tetrasporangia, cystocarps - 483, 2-6.2.54). Reported in the Gulf of Guinea previously from Cameroun, Ghana, Nigeria and Sao Tomé.

Gracilaria disputabilis (Bodard) Bodard

According to the label on the specimens from Fresco (S., ?485, cystocarps - 484, 2-6.2.54) found at «Niveau inférieur des marées, dominant sur rocher horizontal.» and is also known in the Gulf only from Ghana (unpublished).

Gracilaria verrucosa (Hudson) Papenfuss

A few solitary individuals growing in the «alga turf» in the lower eulittoral subzone on moderately sheltered rocks.

Collected at Sassandra (J & S., cystocarps - 6985, - 6869, 30.12.71) and also reported from Cameroun, Ghana, Togo and Sao Tomé.

Source MNHN Paris

Gracilaria sp.

A few small plants collected on «Plateforme d'abrasion au niveau de la basse mer de vive eau, rare.» at Fresco (S., tetrasporangia - 526, 2-6.2.54). The flattened nature of the fronds and the branching is suggestive of *Gracilaria foliifera*.

Grateloupia doryphora (Montagne) Howe

Occuring as widely dispersed plants on rocks and barnacles in moderately sheltered to moderately wave-exposed situations in the eulittoral zone.

Found in the Canal de Vridi near Abidjan (S., cystocarps - 509, 27.1.54, tetrasporangia - 475, 2-6.2.54), Sassandra (J & S., 6855, 30.12.71; A., 7, 6535, 12.12.66) and Cape Palmas (J & S., 6955, 2.1.72) being previously reported in the Gulf from Ghana as *Grateloupia gibbesi*.

Grateloupia filicina (Lamouroux) C. Agardh

Growing in the eulittoral zone in greatest abundance in moderately wave-sheltered situations as loose mats on sand-scoured rocks or where there is freshwater influence, forming only small coarse clumps in very wave-exposed places.

Collected at Tabou (J & S., 6897, 1.1.72), Sassandra (J & S., 6854, 30.12.71), Fresco (A & C., 21, 684, 6569, 12.7.67; S., 479, 480, 2-6.2.54) and at a retty in the Canal de Vridi near Abidjan (S., 505, 27.1.54). Known in the Gulf also from Cameroun, Dahomey, Ghana, Nigeria and Togo.

Griffithsia schousboei Montagne

Occuring as bright red and globose tufts on larger algae such as *Amphiroa*, *Gelidiopsis* and *Corallina* growing in moderately sheltered to moderately wave-exposed situations in the lower part of the eulittoral subzone.

Found at Sassandra (J & S., tetrasporangia - 6870, 30.12.71) and Tabou (J & S., spermatangia - 7006, 1.1.72) and recently reported from Ghana.

* *Gymnogongrus nigricans* Dangeard ?

A few small plants drying almost black have been collected near Sassandra (A., 4, 6541, 12.12.66) in Ivory Coast whilst elsewhere in the Gulf of Guinea it is known from Cameroun, Dahomey and Ghana.

* *Gymnogongrus tenuis* (J. Agardh) J. Agardh

Plants having flattened branches becoming somewhat attenuate towards the tips were gathered on rocks at Fresco (A & C., 18, 681, 6555, 12.7.67; S., 499, 2-6.2.54) and this species has also been reported from Nigeria.

Gymnogongrus spp.

a. – Plants having terete and not noticeably fastigiate branches were collected at Fresco (A & C., 277, 6564, 12.7.67; S., 481, 2-6.2.54) and Cape Palmas (J & S., 6952, 2.1.72).

b. – A larger and more robust plant having flattened branches with acute tips

Source MNHN, Paris

was found as dense clumps on moderately wave-exposed rocks at Tabou (J & S., 6912, 1.1.72) and Sassandra (J & S., 6922, 30.12.71). It is not inconceivable that this might be no more than a form of *Gymnogongrus tenuis*.

Herposiphonia densa Pilger

Growing as low ring-like patches on moderately wave-exposed rocks and lithothamnia in the lower eulittoral subzone though in less exposed situations found often in the «algal turf».

Found at Cape Palmas (J & S., tetrasporangia - 6931, 2.1.72), Tabou (J & S., 6915, 1.1.72) and Sassandra (J & S., 6844, 6856, 30.12.71) being also reported in the Gulf from Cameroun, Ghana and Togo.

* *Herposiphonia tenella* (C. Agardh) Ambronn

Forming small and felty circular or ring-like patches on moderately wave-exposed rocks or lithothamnia in the lower part of the eulittoral zone.

Gathered only on one occasion at Cape Palmas (J & S., 6994, 2.1.72) in Liberia but common in Ghana though not reported from any other countries bordering the Gulf of Guinea.

* *Hildenbrandia prototypus* Nardo

Occuring as dark red patches covering often large areas of rock in the upper eulittoral subzone where exposure to wave action is moderate.

Collected at Tabou (J & S., 6928, 1.1.72) and Sassandra (J & S., 6886, 30. 12.71) in Ivory Coast and Cape Palmas (J. & S., tetrasporangia - 6984, 2.1.72) in Liberia whilst previously reported from Sao Tomé (as *Hildenbrandia rosea*) and Ghana.

* *Hypnea cervicornis* J. Agardh

As intricate cushion-like clumps growing on moderately wave-exposed rocks in the lower part of the eulittoral zone.

Found only at Cape Palmas (J & S., 6950, 6958, 2.1.72) but reported in the Gulf also from Ghana and both the islands of Principe and Sao Tomé.

Hypnea musciformis (Wulfen) Lamouroux

Growing as loose clumps or else forming part of the «algal turf» on moderately sheltered to moderately wave-exposed rocks in the lower eulittoral subzone.

Gathered at Cape Palmas (J & S., tetrasporangia - 6956, 2.1.72), Tabou (J & S., 6911, 1.1.72) and near Sassandra (J & S., 6975, 30.12.71; A., 11, 6536, 12. 12.66), also known in the Gulf from Cameroun, Ghana, Nigeria, Togo, Sao Tomé and Principe.

* *Jania crassa* Lamouroux

Forming small clumps on moderately wave-exposed rocks and as more extensive patches in moderately wave-sheltered tidepools or on sand-scoured beach

Source MNHN Paris

rocks in the lower part of the eulittoral zone.

Found in Ivory Coast at Tabou (J & S., 6905, 7010, 1.1.72), Fresco (S., 488, 2-6.2.54) and Sassandra (J & S., 6865, 6989, 30.12.71 ; A., 12, 6537, 12.12.66) whilst in other parts of the Gulf it has been reported from Ghana and Gabon as *Jania natalensis*.

Jania fastigiata Harvey

Growing in the «algal turf» or over larger algae and is in greatest abundance in moderately wave-sheltered situations in the eulittoral zone.

Gathered at Sassandra (J & S., 6882, 30.12.71) and as a few small and rather fragmentary plants at Cape Palmas (J & S., 6953, 6971, 7002, 2.1.72) being previously only known in the Gulf from Ghana.

* *Lasiothalia* sp.

As a small epiphyte growing on larger algae in a moderately wave-sheltered tidepool at Cape Palmas (J & S., carposporangia - 7000, 2.1.72) and as a few filaments in a collection from Tabou (J & S., 7008, 1.1.72),

This material was identified by Dr. E. WOLLASTON who was not able to give it specific rank until a revision of this little known genus is completed. This genus has not previously been reported from West Africa though it is conceivable that it might in the past have been confused with the closely related *Callithamnion*.

* *Laurencia galtsoffi* Howe

Occuring as erect clumps growing on moderately wave-exposed rocks in the lower part of the eulittoral zone only at Cape Palmas (J & S., 6930, 2.1.72) in Liberia and recently recorded from Ghana.

* *Laurencia intermedia* Yamada

Forming coarse and usually reddish-purple clumps on moderately wave-exposed rocks in the lower eulittoral subzone.

Collected both at Cape Palmas (J & S., 6774, 6993, 2.1.72) and Sassandra (J & S., 6863, 30.12.71) whilst elsewhere in the Gulf of Guinea it is only known from Ghana where it is the most common *Laurencia* species.

* *Laurencia nidifica* J. Agardh ?

Just a few fragments have been collected from Sassandra (A., tetrasporangia - 3, 6540, 12.2.66) and these are insufficient to make an absolutely positive determination. This species has previously been reported in the Gulf from Ghana.

* *Laurencia tenera* Tseng

Growing usually as low clumps or more extensive spongy mats and only very rarely epiphytic, particularly common in moderately wave-sheltered tidepools but occasionally in wave-exposed situations.

Source MNHN Paris

Found at Cape Palmas (J & S., tetrasporangia - 6951, 2.1.72), Sassandra (J & S., 6888, 30.12.71) and Fresco (S., cystocarps - 487, 2-6.2.54) whilst also reported from Ghana and Togo.

Lophosiphonia reptabunda (Suhr) Kylin

Occuring as tufts or forming extensive mats mixed with other small algae in cracks, crevices and beneath rock overhangs, occasionally on the lower surface and the cut ends of stranded logs; grows in the upper eulittoral subzone though most commonly to be found in the littoral fringe.

Collected at Fresco (S., cystocarps and tetrasporangia - 493, 2-6.2.54) and Sassandra (J & S., 6987, tetrasporangia - 6976, 29.12.71) in Ivory Coast and known in the Gulf also from Cameroun and Ghana as *Lophosiphonia obscura*.

**Peyssonnelia polymorpha* (Zanardini) Schmitz

Forming dark reddish-brown crusts in the lower part of the eulittoral zone growing over moderately wave-exposed rocks.

Found only at Sassandra (J & S., tetrasporangia - 6883, 30.12.71) in Ivory Coast having not been reported from elsewhere in the Gulf of Guinea.

Platysiphonia miniata (C. Agardh) Börgesen

As soft filamentous tufts, often mixed with other algae, growing on moderately wave-sheltered rocks in the lower eulittoral subzone or as small patches on the floor of shallow and wave-sheltered tidepools.

Collected at Tabou (J & S., 7008, tetrasporangia - 6914, 1.1.72), Sassandra (J & S., 6917, tetrasporangia - 6925, - 6990, 1.1.72) and Fresco (S., tetrasporangia - 492, 2-6.2.54) having been previously reported in the Gulf only from Ghana.

Polysiphonia ferulacea Suhr *ex* J. Agardh

Growing as hair-like tufts or low mats both on rocks and large barnacles (*Balanus tintinnabulum*) in the lower eulittoral subzone in moderately wave-exposed situations or in the «algal turf» in places where the wave action is less.

Gathered at Cape Palmas (J & S., 6943, tetrasporangia - 6942, - 6966, - 7001, 2.1.72), Sassandra (J & S., 6856, 30.12.71) and Fresco (S., cystocarps and tetrasporangia - 489, 2-6.2.54) having previously been reported both from Nigeria and Ghana.

Polysiphonia sp.

As tufts of fine filaments growing on moderately wave-sheltered rocks and sometimes in tidepools in the lower part of the eulittoral zone at Sassandra (J & S., tetrasporangia - 6844, 30.12.71) and Cape Palmas (J & S., tetrasporangia - 6961, 2.1.72). This unidentified species has irregularly divided, flexuous filaments, about 40 - 50 μm in diameter, arising from a creeping base whilst the number of pericentral cells is just four.

Source MNHN Paris

* *Pterocladia capillacea* (Gmelin) Bornet et Thuret

Growing as a loose mat on moderately wave-sheltered rocks in the upper part of the lower eulittoral subzone.

Found at Cape Palmas (J & S., 6934, 2.1.72) and Fresco (A & C., tetrasporangia - 19, - 682, 6556, 12.7.67) having been reported on the Guinea Coast from Cameroun (as *Pterocladia pinnata*) and Ghana.

Taenioma perpusillum (J. Agardh) J. Agardh

Occuring as low ring-like patches on rocks, lithothamnia and occasionally over *Ralfsia*, growing in moderately wave-sheltered situations and usually found in the «algal turf» in more wave-sheltered places.

Collected at Cape Palmas (J & S., tetrasporangia - 6964, - 6968, 2.1.72), Sassandra (J & S., 6972, 6873, tetrasporangia - 6923, - 6871, 30.12.72) and Fresco (S., tetrasporangia - 496, 2-6.2.54) whilst having previously been reported in the Gulf only from Ghana.

* *Wrangelia argus* (Montagne) Montagne

Growing as soft and plumose tufts on *Laurencia tenera* in moderately wave-sheltered situations in the lower eulittoral subzone.

Found at Cape Palmas (J & S., carposporangia - 7006, 2.1.72) in Liberia and known also from Cameroun (unpublished), Ghana and Togo.

CYANOPHYTA

Anacystis dimidiata (Kützing) Drouet et Daily

Growing together with filamentous blue-green algae as a scum floating on the surface of pools in the littoral fringe which are influenced only by sea spray.

Found at Cape Palmas (J & S., 6959, 2.1.72) in Liberia and previously reported from marine habitats in the Gulf of Guinea from Ghana and the offshore island of Sao Tomé (as *Chroococcus turgidus* var. *submarinus*).

Microcoleus lyngbyaceus Gomont

Occuring mixed with larger algae or forming small dark greenish patches in the upper eulittoral subzone, occasionally as a scum with other blue-green algae on the surface of pools in the littoral fringe.

Collections from Cape Palmas (J & S., 6965, 6970, 6959, 2.1.72), Tabou (J & S., 6918, 1.1.72) and Sassandra (J & S., 6977, 30.12.72) whilst also known in the Gulf from Cameroun, Dahomey, Gabon, Ghana, Nigeria, Principe, Sao Tomé and Togo.

Oscillatoria lutea Gomont

Forming a dirty yellowish-green slime on open rocks in the littoral fringe at the entrance to the Tabou River (J & S., 6895, 1.1.72) in Ivory Coast having previously been reported from Ghana.

Source MNHN, Paris

Schizothrix calcicola Gomont

Growing together with other blue-green algae as small slimy patches on moderately wave-exposed rocks in the upper eulittoral subzone and also as a scum on the surface of pools in the littoral fringe.

Found only at Cape Palmas (J & S., 6965, 6959, 2.1.72) and known previously from Dahomey, Ghana, Nigeria and Togo.

Schizothrix mexicana Gomont

Forming a lining over the floor of a shallow pool in the littoral fringe at the entrance to the Tabou River (J & S., 6918, 1.1.72) in Ivory Coast and known previously from Ghana and Nigeria in the Gulf of Guinea.

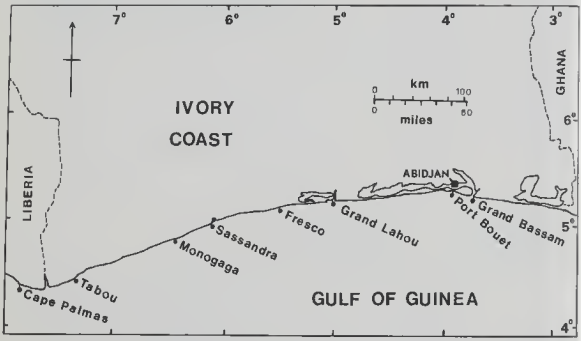

Fig. 1 – Map showing the localities along Ivory Coast and Cape Palmas in Liberia from which collections were made.

ACKNOWLEDGEMENTS

I am most grateful to Pr. R. SOURIE, Laboratoire de Zoologie, Université de Poitiers, for information regarding his collection of marine algae from Ivory Coast and to Pr. J. FELDMANN, Laboratoire de Biologie Végétale Marine, Université de Paris, for loaning me these plants. Thanks go to the Centre O.R.S.T.O.M. d'Adiopodoumé in Abidjan and the Département de Biologie, Université d'Abidjan, for sending me what collections they held. I am also grateful to Dr. F. DROUET, Academy of Natural Sciences, Philadelphia, U.S.A., for determining the Cyanophyta, to Dr. E. POST, Kiel, West Germany, for giving her opinion on the brakish-water algae, and to Dr. E. WOLLASTON, Botany Department, University of Adelaide, Australia, for identifying the *Lasiothalia*. Finally I wish to express my thanks to

Source MNHN, Paris

the Sous-Préfet at Tiassale and Tabou for their hospitality when in Ivory Coast and special thanks go to Mr. F.O.K. SEKU for his most able assistance during all phases of this study.

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SOME MARINE BENTHIC ALGAE FROM PITCAIRN ISLAND

R. T. TSUDA *

SUMMARY. — The 21 species reported here include 4 Cyanophyta, 7 Chlorophyta, 5 Phaeophyta, and 5 Rhodophyta. The majority of the species are Malayan in origin, except for the branching form of *Lobophora variegata* (Lamx.) Womersley (*Pocockiella nigrescens* (Sonder) Papenfuss *sensu* Papenfuss, 1943) which seems to be localized around Australian or adjacent shores. All specimens are deposited in the author's Herbarium at the University of Guam.

RÉSUMÉ. — De cette île volcanique 21 espèces ont été identifiées. Elles sont d'origine malaise, à l'exception de la forme branchue de *Lobophora variegata* (Lamx.) Womersley qui semble être localisée sur les rivages australiens adjacents.

I. INTRODUCTION

The marine benthic algae of those islands (Tuamotus, Marquesas and Pitcairn) situated on the eastern fringe of Polynesia between 120° and 150° W longitude are the least known in the tropical-subtropical Pacific Ocean. The reason for our limited knowledge of the algae in this area does not reflect the lack of interest but the logistic difficulties in getting to these islands.

The only algal studies, thus far, reported from this area were carried out on Raroia Atoll in the Tuamotus by DOTY (1954) and NEWHOUSE (1954). However, no systematic compilation of algae has been made for the Tuamotus, except for the paper on the blue-green algae by NEWHOUSE (1954). There has also been no published account on the marine algae of the Marquesas Islands. We expect this situation to be changed by Dr. G. Valet of the University of Paris who has informed me that he is presently studying the collections made from this island group. The algae from the volcanic island of Pitcairn has never been reported on nor has any listing of algae appeared for the three adjacent coral islands (Henderson Island, Ducie Atoll, and Oeno Atoll).

When a proposed trip was being planned by the B. P. Bishop Museum to this area of the Pacific, I prevailed upon Dr John E. Randall to collect any algal spe-

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Rev. Algol., N. S., 1976, XI, 3-4 : 325-331.

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cimens he could find from the area. The small collection reported here represents algal specimens collected by him from Pitcairn Island during december 1970 and january 1971. In addition, a collection of algae was also made from the Marquesas which I forwarded to Dr Valet to be incorporated into his own studies on the marine algae from this island group.

II. BRIEF DESCRIPTION OF ISLAND

Pitcairn Island (24° 04' S lat., 130° 06' W long.) is a volcanic island about 4.5 km in circumference and 360 m high which lacks the typical coral reef formations found on most Pacific islands. The climate is subtropical with air-temperature ranging from 20° C in august and september to 25° C in february and march. The average annual rainfall is about 175 cm (70 inches); the summer months are slightly wetter than the winter months. The tidal range is about one meter. For further information on the physical aspects of this island, I refer you to CARTER (1967) from which most of the above information is taken.

III. STATION DESCRIPTIONS

The five stations where algal specimens were collected are described below. The specimen numbers are those of the author.

Station 1 - Large tidepools and on rocks awash at shore, West Harbor, december 29, 1970. (RT 4430 - 4445).

Station 2 - Large tidepool in surge zone, Christian's Point, december 31, 1970. (RT 4446 - 4451).

Station 3 - Off Gudgeon Harbor, 13 m deep, january 2, 1971. (RT 4452 - 4460).

Station 4 - Large pool, 5 m deep, St. John, january 7, 1971. (RT 4461 - 4463).

Station 5 - Boulder bottom with some sand and live corals, 21 m deep, south coast, january 20, 1971. (RT 4464).

IV. ANNOTED SPECIES LISTING

1. Division Cyanophyta

Microcoleus lyngbyaceus (Kütz.) Crouan
DROUET, 1968 : 262.

Station 1 (RT 4433a) - The filaments are intermixed with *Hormothamnion enteromorphoides*.

Hormothamnion enteromorphoides Bornet & Flahault
DAWSON, 1954 : 379, fig. 3n.

Station 1 (RT 4433a) - The filaments, 5 to 6 μm in diameter, are beadlike in appearance and possess conspicuous intercalary heterocysts.

Source MNHN, Paris

Brachytrichia quoyi (Ag.) Bornet & Flahault
TILDEN, 1900 : 294, pl. 20 (Fig. 18).

Station 1 (RT 4445) - This alga appears as dark green hollow colonies about 5 mm in diameter. The beaded branched filaments, 2.5 to 4 μm diameter, taper at one end and appear hair-like. Basal heterocystes are conspicuous and occasionally intercalary heterocysts are present.

Calothrix pilosa Harvey
FAN, 1956 : 130, fig. 2.

Station 1 (RT 4441b) - The few filaments present are epiphytic on the green alga *Dictyosphaeria cavernosa*.

2. Division Chlorophyta

Cladophora coelothrix Kütz.
VAN DEN HOEK, 1963 : 40, fig. 55-78.

Station 1 (RT 4435b) - The alga appears in tufts, about 15 mn high, and possesses sparingly branched filaments which arise in a dichotomous or trichotomous manner. The cells are 350 to 600 μm long, and vary from 75 to 100 μm in diameter at the base. However, the cells at the apex range from 25 to 30 μm in diameter.

Bryopsis pennata Lamx.
EGEROD, 1952 : 370, fig. 7.

Station 3 (RT 4458) - This alga consists of pinnate siphons up to 25 mm high.

Caulerpa pickeringii Harvey & Bailey
WEBER VAN BOSSE, 1898 : 272, pl. 11, fig. 7-8; TRONO, 1968 : 167, pl. 15, fig. 5.

Station 3 (RT 4453) - This alga, up to 5 cm high, possesses whorls of branching, ramuli which completely clothe the rizomes and assimilators (fig. 1). The only other Pacific islands on which this species has been reported are from Yap (TRONO 1968), Tahiti and the Tuamotus (WEBER VAN BOSSE 1898).

Caulerpa racemosa (Forsskal) J. Ag.
WEBER VAN BOSSE, 1898 : 357, pl. 31, fig. 5-8.

Station 1 (RT 4436, var. *macrophysa*), Station 2 (RT 4449, var. *peltata*).

Halimeda incrassata (Ellis) Lamx.
DAWSON, 1957 : 109, fig. 13; HILLIS, 1959 : 365.

Station 1 (RT 4432), Station 4 (RT 4463) - The Pitcairn Island specimens do not resemble the typical *Halimeda incrassata* specimens as found in the Micronesian area, but strongly resemble DAWSON's (1957) figure of *H. tridens f. lamourouxii* (J. Ag.) Weber van Bosse which HILLIS (1959) later places under *H. incrassata* (fig. 2). My specimens are bushy with a small discoid holdfast. The reniform segments are more or less similar in size and never exceed 3 mm in length and 4 mm in width. Two tiers of utricles are present. The secondary utricles, 25μm long and 20 μm wide, give rise to 2 to 4 peripheral utricles which are about 32 μm and 20 to 24 μm wide.

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Cladophoropsis gracillima Dawson
DAWSON, 1950 : 149, fig. 12-13.
Station 1 (RT 4433b) - The filaments are sparingly branched and possess cells which are up to 65 μm in diameter and 1 mm long. Shorter basal cells, about 250 μm long, are occasionally present.

Dictyosphaeria cavernosa (Forsskal) Boerg.
EGEROD, 1952 : 350, fig. 1b-f, 2f and 2g.
Station 1 (RT 4441) - A small specimen, 1.6 cm across, is all that is present in the collection. However, the monostromatic thallus and the absence of trabeculae seem to place the specimen in this species.

3. Division Phaeophyta

Ectocarpus breviarticulatus J. Ag.
DAWSON, 1954 : 398, fig. 14a-b.
Station 1 (RT 4437) - The specimen, intermixed with *Sphacelaria tribuloides*, is sterile but possesses the characteristic hamate branches.

Sphacelaria tribuloides Meneghini
DAWSON, 1954 : 400, fig. 14i-j.
Station 1(RT 4444) - The propagulae of these specimens possess «horns» which are not as protrusive as the Micronesian of Hawaiian specimens but still fall within the circumscription for this species.

Dictyota acutiloba J. Ag.
SETCHELL, 1926 : 93.
Station 2 (RT 4450) - These specimens form loose clumps which are similar in habit to growth-forms found in Hawaii. The branches are usually twisted and possess acute apices. Reproductive bodies, which on these plants can be either oogonia or potential tetraspores prior to cleavage, are scattered throughout the median surface of the thalli. This species has been reported from Tahiti by SETCHELL (1926).

Lobophora variegata (Lamx.) Womersley
WOMERSLEY, 1967 : 221, PAPENFUSS, 1943 : 467, fig. 1-10; TAYLOR, 1971 : 150, fig. 16-18.
Station 2 (RT 4447), Station 3 (RT 4452, RT 4454), Station 4 (RT 4461), Station 5 (RT 4464) - The Pitcairn Island collection consists of one prostrate specimen (RT 4454), (fig. 3). All of the other specimens are of the branching form. It is with considerable hesitation that I place both forms under this one species, since our prostrate Guamanian specimens never transform into the branching form.

Sargassum coriifolium J. Ag.
WOMERSLEY and BAILEY, 1970 : 295, fig. 6, pl. 24, fig. 14.
Station 1 (RT 4430, RT 4442), Station 2 (RT 4446, RT 4448), Station 3 (RT 4455, RT 4456), Station 4 (RT 4462) - The majority of the specimens, although showing a range in variation, seem to fit the description and figures of the Solomon Island specimens (WOMERSLEY and BAILEY 1970). All of

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the thalli possess terete branches (fig. 4). The «leaves» vary considerably in size and shape varying from entire, dentate, or duplicate. All specimens are sterile except for one specimen (RT 4430) which possesses narrow straplike «leaves» with elongate terete receptacles unlike the receptacles illustrated by WOMERSLEY and BAILEY (1970). Further collections and observations are needed of fruiting thalli before a definite determination can be made.

4. Division Rhodophyta

Gelidiopsis intricata (Ag.) Vickers
DAWSON, 1954 : 423, fig. 34.
Station 1 (RT 4438), Station 3 (RT 4457) - The specimens occur in tufts and possess terete to compressed branches up to 500 μm in diameter. One intercalary stichidium is present which has not been attributed to this species.

Corallina cuvieri Lamx.
Station 1 (RT 4434), Station 3 (RT 4460) - These fertile specimens were identified by Dr. H. W. Johansen to whom I am most grateful.

Botryocladia skottsbergii (Boerg.) Levring
DAWSON, 1956 : 52, fig. 48.
Station 1 (RT 4443) - The collection consists of a single thallus which possesses small subglobose vesicles about 3 mm in diameter on a 5 mm long branching stalk.

Centroceras clavulatum (C. Ag.) Montagne
DAWSON, 1954 : 446, fig. 54h.
Station 1 (RT 4435a) - The sparingly branched thalli are 100 to 150 μm in diameter and possess the characteristic cellular spines at the nodes.

Chondria intricata Okamura
OKAMURA, 1912 : 180, pl. 99.
Station 2 (RT 4451) - It is with hesitation that the Pitcairn Island specimen is placed here.

ACKNOWLEDGEMENTS

I am grateful to Dr. John E. RANDALL of the B. P. Bishop Museum for taking the time from his busy fish collecting schedule to collect algal specimens for me. I also thank Dr. H. William JOHANSEN of Clark University for his determination of *Corallina cuvieri* Lamx.

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Fig. 1. — *Caulerpa pickeringii* Harvey and Bailey, habit; Fig. 2 — *Halimeda incrassata* (Ellis) Lamx., habit; Fig. 3 — *Lobophora variegata* (Lamx.) Womersley, habit of branching form; Fig. 4. — *Sargassum corilifolium* J. Ag., habit.

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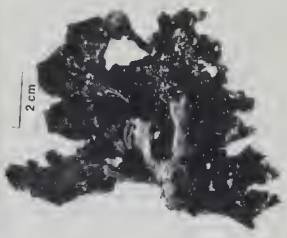

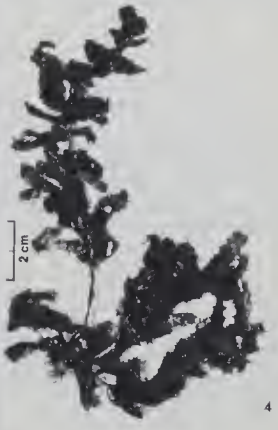

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ALGAL FLORA OF THE RICE-FIELDS AROUND DEHRADUN, INDIA

M. KHAN & A. MATHUR *

SUMMARY. — 24 species of Cyanophyta and 24 species of Chlorophyta collected from the rice-fields at the village Majra, situated near Clement Town, Dehradun have been recorded. The successive occurence of various algal species through the months july-october are discussed in detail. The algal communities like tychophytes, benthophytes and epactiphytes are predominent while planktophytes and periphytes are found to be comparatively very rare in the rice-fields. During present survey 2 genera (*Draparnaldiopsis* and *Zygogonium*), 12 species of Cyanophyta and 17 species of Chlorophyta have been recorded for the first time from Dehradun.

RÉSUMÉ. — 24 espèces de Cyanophycées et 24 espèces de Chlorophycées ont été récoltées dans les rizières du village de Majra, situé près de Clement Town (Dehradun). La succession des diverses espèces d'algues de juillet à octobre est analysée : les communautés tychophytes, bentophytes et epactiphytes sont prédominantes alors que les planctophytes et les périphytes sont rares. Au cours de cette étude 2 genres (*Draparnaldiopsis* et *Zygogonium*) et 12 espèces de Cyanophycées ainsi que 17 espèces de Chlorophycées ont été récoltées pour la première fois à Dehradun.

1. INTRODUCTION

Algal survey reported so far (GONZALVES et GANGLA 1949; GUPTA 1966; SHUKLA 1971; SINGH 1939, 1961; SUBRAHMANYAN et al. 1965; VENKATARAMAN 1971) from different parts of India can not be deemed as adequate and commensurative with the needs of the wast rice-growing areas spread out in many parts of the country. Also, there exist no previous comprehensive records on the algal flora of rice fields of Doon Valley, Western Uttar Pradesh (cf. KHAN 1970 a, b et c; KHAN & USHA 1971; KHAN & KUMARI 1972; KHAN & BARTHWAL in press).

a. LOCATION AND PERIOD OF STUDY

The area under study is Clement Town which is situated on both sides of Saharanpur road near village Majra at the altitude of 548 meters. Observations have been made on the algal flora of the rice-fields from the month of july till the end of october during the years 1971 and 1972, which coincide with the sowing har-

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Rev. Algol., N. S., 1976, XI, 3-4 : 333-337.

Source MNHN, Paris

vesting months of rice crop in the area.

b. CLIMATE AND SOIL CONDITIONS

The climate of the valley is best suited for the cultivation of the rice. The mean temperature in the last week of june is 26° C and in october 21° C, which is ideal for sowing and maturity of the crop respectively. During the month of july climate is very humid (84 - 94%) due to heavy rain fall (472 - 599 mm). The water table is 12 meters below the surface and irrigation facilities are adequate. The soil is rich loamy and one of the best in the whole of Dehradun valley.

II. SUCCESSION OF ALGAE IN NATURE

The mansoon usually sets in, in this region in the third or fourth week of june and the fields are ploughed after one or two rain falls. The early variety of paddy is sown in the upland fields in the first week of july. As the fields are in a continuously disturbed state, there is apparently no growth of algae. The extra water is drained into low lying areas and the low land fields are therefore flooded. The common algae (Table I) in the upland fields were *Cylindrospermum majus, C. stagnale, Anabaena torulosa, Aulosira aenigmatica* and *Oedogonium vanoyeanum*. Species of *Spirogyra* and *Zygnema* were in a vegetative state. *Anabaena torulosa, Cylindrospermum majus* and *C. stagnale* were found as elongated colonies on moist soil immersed in three to five centimeters deep in water. *Spirogyra* grew in drains, along the sides or where water had accumulated in the fields. In addition *Microcoleus vaginatus* and *Aulosira aenigmatica* formed a green or bluish green stratum on moist soil in some fields. The low land fields are usually in knee deep water and as the water was muddy no growth of algae was therefore visible during this month.

There was heavy rain fall during the first fortnight of August, and the maximum and minimum temperature varied from 22 to 26° C and 26 - 30° C respectively. The high temperature and humidity (49 - 97%) provided very suitable conditions for the growth of algae and these were on the whole found to be very abundant. The most common algae found during this period were the species of *Cylindrospermum* and *Microcoleus*, which covered the entire surface of the soil in some of the upland fields. The well developed colonies assumed a palmate form with long finger like processes.

In a few fields a very prominent associations of *Nostoc, Cylindrospermum* and *Microcoleus* were found to cover the surface of water as leathery dirty-bluish stratum. As the water receded in these fields the algal stratum remained sticking to the stalks of paddy plants. Among the other forms *Mougeotia, Chaetophora* and *Nitella* were conspicuous. During the later half of the month of august a number of other forms like *Nostoc punctiformae, Oscillatoria annae, O. sancta, Anabaena sphaerica, A. iyengarii* and *Scytonema hofmanni* were present, the latter which was present from the beginning of the month spread considerably on moist soil in the fields.

Source MNHN Paris

The low land water logged fields flooded due to heavy and continuous rains were filled with disturbed and muddy water, due to which no algal forms were apparently growing during the second fortnight. Only a few free floating masses of *Anabaena, Sirogonium inflatum* and *Lyngbya martensiana* have been collected.

There were light rains during the earlier part of september and the maximum and minimum temperature varied from 17 - 21° C to 26 - 30° C respectively. During the later half of the month there is a dry spell and temperature showed a little variation. Many of the upland fields dry up and are harvested. Species of *Cylindrospermum* was still conspicuous during this month. At the end of the month it desappeared almost completely. The abundant algal species during this period were *Scytonema hofmanni, Nitella dictyosperma, N. translucens. Chara* appeared later in abundance along with little amount of *Draparnaldiopsis indica*. In a few fields *Chaetophora elegans, Scytonema hofmanni* and *Nostoc* continued to be prominent component of the algal vegetation till the fields dried up.

In the low land fields number of algae increased considerably. *Scytonema coactile* which occurs in free floating masses formed bright bluish green cushion of erect filaments on moist soil along the sides of the fields. *Microcoleus vaginatus* appeared to be very common on moist soil in and around these fields. Gradually a very profuse growth of *Chara* and *Nitella* took place in most of the fields which were in vegetative condition. *Aulosira fertilissima* was common in most of the fields. A number of chlorophycean members like *Zygnema collinsianum, Zygogonium indicum* and species of *Spirogyra* were also found.

In october the upland fields were completely dry and rice crop had already been harvested by now. No growth of the algae was apparent. At this time the low land fields were rich in algal growth. The water level fell considerably and there was an abundant growth of *Mougeotia* and *Aulosira fertilissima*. Species of *Spirogyra* and *Zygnema* were the other prominent constituents of the algal vegetation. In the middle of the october species of *Chara, Nitella, Aulosira* and *Oedogonium* were abundant in low land fields.

III. DISCUSSION

It is apparent from the table-I and also from the foregoing succession accounts that the species of *Cylindrospermum* are common during the beginning and *Scytonema* and *Oedogonium* are at the end of the season.

Though the percentage of blue-green and green algae are equal but so far the frequency and dominance are concerned, the blue-green algae are very predominent. Generally, the blue-green algae show a overwhelming preponderance over the other classes of algae particularly Chlorophyceae in India (GONZALVES & GANGLA 1949; GUPTA 1966; SUBRAHMANYAN et al. 1965; VENKATARAMAN 1971) as against the temperate soil where reverse is the case. However, in the fields under discussion green algae are equally dominant as it was shown earlier by SINGH (1939) and SHUKLA (1971).

Source MNHN, Paris

The members of Cyanophyta are abundant in early months of july and august while during september and october, the members of Chlorophyta are predominent. The present investigation shows that the growth of the algae in nature is controlled to a great extent by the seasonal variations as well as by ecological conditions to some extent as it was earlier shown by GUPTA (1966).

In the rice-fields of U. P. and Bihar occur a dominant and widespread nitrogen-fixing algal community of blue-green algae constituted mainly by *Aulosira fertilissima* (SINGH 1936, 1961; SHUKLA 1971). VENKATARAMAN (1971) and SUBRAHMANYAN et al. (1965) also have recorded ubiquitous occurence of *Aulosira fertilissima* in the states of Madras and Kerala and Orissa respectively. However, in Maharashtra this genus has not been recorded from the rice fields (GONZALVES and GANGLA 1949).

The distribution of *Charophyta* is very interesting. Species of *Chara* are confined to central regions of the fields whereas the species of *Nitella* are found only on the margins.

The algal species which were growing in the rice-fields, on the basis of their habitat may be categorised into five algal communities as tychophytes, bentophytes, epactiphytes, periphytes and planktophytes. Planktophytes and periphytes are comparatively rare.

It is also interesting to note that in the rice-fields of Doon valley members of Volvocales, Chlorococcales, Ulotrichales and Cladophorales are entirely absent in contrast to the observations of SHUKLA (1971) and GONZALVES and GANGLA (1959).

ACKNOWLEDGEMENT

The authors are grateful to Dr. Y. S. R. K. SARMA, Professor of Botany, Benaras Hindu University, Varanasi-5, for his valuable advice.

Source MNHN, Paris

TABLE I. Algal species showing their frequency in rice-fields

* Recorded for the first time from Dehradun, a - abundance, c - common, r - rare, B - Benthophytes, E - Epactiphytes, P - Periphytes, Pl - Planktophytes, T - Tychophytes.

S. N.	TAXA	Community Type	July	Aug.	Sept.	Oct.
1.	*Oscillatoria annae* Van Goor	B		c		
2.	*O. *sancta* (Kutz.) Gomont	B		c		
3.	*O. obscura* Bruhl et Biswas	B			r	r
4.	*O. subbrevis* Schmidle.	B			r	
5.	*Lyngbya martensiana* Menegh.	B		r		
6.	*Microcoleus vaginatus* (Vaucher) Gomont.	B	c	c	c	
7.	*Cylindrospermum majus* Kutz.	P	c	c		
8.	**C. stagnale* (Kutz.) Born.et Flah.	P	c	c		
9.	*C. doryphorum* Bruhl et Biswas	P			c	c
10.	*Nostoc punctiforma* (Kutz.) Hariot.	T		r	r	
11.	*N. muscorum* Ag.	B			c	
12.	**N. pruniforme* (L.) Ag.	T			r	r
13.	**Anabaena sphaerica* var. *attenuata* Bharad.	T		c	c	
14.	**A. oryzae* Fritsch.	T			c	c
15.	**A. iyengarii* var. *tenuis* Rao	T		r	c	
16.	**A. torulosa* (Carm.) Lagerh.	B	c			
17.	**Aulosira fertilissima* var. *tenuis* Rao	Pl			c	a
18.	**A. aenigmatica* Fremy	B	c			
19.	*A. prolifica* Bharadwaja	Pl		c	c	
20.	*Scytonema coactile* Mont. *ex* Born.et Flah.	T			c	
21.	**S. bohneri* Schmidle	T			a	
22.	**S. hofmanni* Ag.	P		c	a	
23.	**S. bewsii* Fritsch et Rich	T			c	
24.	*S. mirabile* (Dillw.) Born.	T			c	
25.	**Mougeotia drouetii* Transeau	T		c	c	a
26.	**M. laetivirens* (Braun)	T				a
27.	*Zygnema collinsianum* Transeau	T	c	c	c	c
28.	**Zygogonium indicum* Randhawa	T			c	
29	**Spirogyra parvula* (Trans.) Czurda	E			r	
30.	**S. submaxima* Transeau	E	r	c	c	
31.	**S. rectangularis* Transeau	E			r	
32.	**Sirogonium inflatum* Dixit	T		r	c	
33.	**Oedogonium hindustanense* Kamat	E				c
34.	**O. crassum* (Hassal) Wittrock	E				c
35.	*O. fragile* var. *Abyssinicum* Hirn.	E				c
36.	**O. hirnii* Gutwinskii	P			c	c
37.	**O. vanoyeanum* Gauth-Liev.	E	c			r
38.	**Draparnaldiopsis indica* Bharadwaja	E			r	
39.	*Chaetophora elegans* (Roth.) Agardh	P		r	a	a
40.	*Nitella acuminata* Braun	E	r	c		
41.	**N. translucens* Agardh	E			a	a

Source MNHN Paris

42.	*N. flagellifera* Groves et Allen	E	c	c	c
43.	*N. dictyosperma* Groves	E		a	c
44.	*N. pseudotenuissima* Kundu	E	r	c	c
45.	*Chara burmanica* Pal	B		c	c
46.	*C. vulgaris* Linn.	B	c	a	c
47.	*C. contraria* Kutz.	B		c	a
48.	*C. bharadwajae* Sarma et Khan	B	c	c	r

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Source MNHN Paris

BOURRELLYODESMUS
NOUVEAU GENRE DE DESMIDIACEES

Pierre COMPERE *

Depuis que TEILING (1948, 1967) a reclassé dans le genre *Staurodesmus* les Desmidiacées à membrane lisse pourvues d'une seule épine à chaque angle de la cellule, le genre *Arthrodesmus*, tel qu'il est compris par BOURRELLY (1966, p. 432) ou par COUTÉ et ROUSSELIN (1975, p. 115) est devenu extrêmement hétérogène, groupant, d'une part des espèces à membrane lisse pourvues de plusieurs épines à chaque angle et d'autre part des espèces à membrane ornementée pourvues d'une seule épine à chaque angle. En bonne logique, on ne peut laisser dans le même genre les sections *Polyancanthium* et *Ornatae*, qui ne diffèrent de *Staurodesmus* que par un seul caractère (nombre d'épines par angle ou ornementation de la membrane) mais qui diffèrent l'une de l'autre par ces deux caractères réunis.

Nous avons montré par ailleurs (COMPERE 1976a) que le nom de genre *Arthrodesmus* Ralfs 1848 (Desmidiacées), homonyme postérieur de *Arthrodesmus* Ehr. 1838 (Scénédesmacées) est un nom illégitime et qu'il ne paraît pas très opportun de le conserver en raison des vues divergentes exprimées récemment par divers auteurs (BOURRELLY, loc. cit.; BICUDO 1975a) sur ses limites et sur sa typification.

La plus grande partie des espèces groupées jusqu'ici dans le genre *Arthrodesmus* (section *Tetracanthium*, à membrane lisse et angles de l'hémisomate portant une seule épine) ont déjà été reclassées par TEILING au sein de son nouveau genre *Staurodesmus*; on pourrait y joindre certaines espèces de la section *Octacanthium* comme *A. mucronulatus* : la belle étude que BICUDO (1975b) vient de consacrer à la variabilité de cette espèce, notamment en ce qui concerne le nombre et la disposition des épines, montre bien qu'il est impossible de la séparer, au niveau générique, des espèces du genre *Staurodesmus* (voir notamment ses figures 3, 4, 5, 6 et 7, montrant des spécimens à une épine par angle et des spécimens dichotypiques, où un des hémisomates montre deux épines par angle et l'autre une seule épine par angle).

D'autres espèces des sections *Octacanthium* et *Polyacanthium*, portant quatre, six ou un plus grand nombre d'épines par hémisomate, trouveraient proba-

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Rev. Algol., N. S., 1976, XI, 3-4 : 339-342.

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blement mieux leur place dans le genre *Xanthidium*; cela a déjà été proposé par RALFS (1848) pour *Xanthidium octocorne* Ralfs et par DEFLANDRE (1929) pour *Xanthidium impar* (Jacobs.) Defl. Une révision du genre *Xanthidium* et de ces deux sections d'*Arthrodesmus* serait certainement des plus utiles pour nous fixer sur ce point.

Reste alors le cas des espèces à membrane ornementée, pourvues d'une seule épine de chaque côté de l'hémisomate, comme par exemple *Arthrodesmus heimii* Bourr., connu de diverses parties de l'Afrique et que nous retrouvons dans quelques récoltes de la région du lac Tchad (COMPERE 1976b). Il n'est pas possible d'en faire un *Staurodesmus*, à cause de l'ornementation de sa membrane; on ne peut non plus le rapporter au genre *Xanthidium*, puisqu'il ne présente qu'une seule épine de chaque côté de l'hémisomate. On a bien proposé d'en faire un *Cosmarium* (LIND 1971, p. 548) mais nous pensons, avec COUTÉ et ROUSSELIN (1975, p. 115), qu'il n'est pas opportun de réintroduire dans le genre *Cosmarium* une forme possédant de telles épines latérales, et d'ajouter ainsi à l'hétérogénéité de ce genre énorme, déjà beaucoup trop hétérogène. Finalement, la seule solution respectant une certaine homogénéité des différents genres impliqués paraît bien être la création d'un nouveau genre pour ce dernier groupe d'anciens *Arthrodesmus*. Cette conclusion resterait d'ailleurs valable si le nom *Arthrodesmus* devait être conservé, soit dans le sens de BICUDO (1975a) pour ce qui est actuellement appelé *Staurodesmus*, avec *A. convergens* comme type, soit dans le sens de BOURRELLY (1966), avec *A. octocornis* comme type, pour les espèces à membrane lisse possédant deux ou plusieurs épines de chaque côté de l'hémisomate. Nous sommes heureux de pouvoir dédier ce nouveau genre de Desmidiacées au Professeur P. BOURRELLY, du Muséum National d'Histoire Naturelle de Paris, qui a été le premier à découvrir son espèce la plus caractéristique.

BOURRELLYODESMUS COMPERE, *GEN. NOV.*

a Staurodesmo membrana in media parte incrassata, verrucis vel scrobiculationibus ornata differt; a Xanthidio angulis unispinosis differt.

Semi-cellulae ellipsoidales vel reniformes, ab apice visae ellipticae, spina unica utroque munitae, in media parte incrassatae, verrucosae vel scrobiculatae.

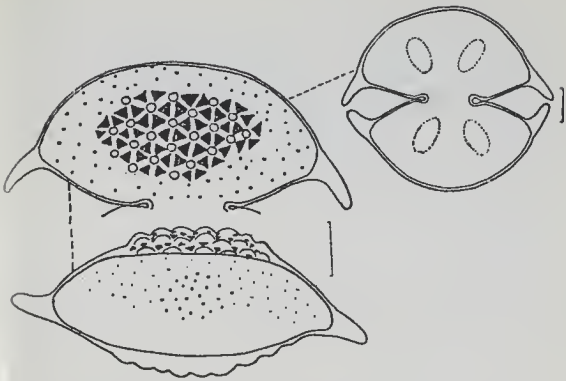
Species typica : *BOURRELLYODESMUS HEIMII* (Bourrelly) Compère, comb. nov., fig. 1.

Basionyme : *Arthrodesmus heimii* Bourr., *Bull. I.F.A.N.* 19 : 1079, fig. 105, 106 (1957).

Synonymes : *Arthrodesmus stellifer* Grönblad & Scott, *Acta Bot. Fenn.* 58 : 38, fig. 265-267 (1958).

Cosmarium tagmasterion Sc. & Presc. var. *africanum* Lind, *Nova Hedwigia* 22 : 548, pl. 4 fig. 5, pl. 10, fig. 18 (1971).

Source MNHN Paris



ig. 1 : Iconotype de *Bourrellyodesmus heimii*; reproduction des figures originales de *Arthrodesmus heimii* (BOURRELLY 1957 : pl. 12, fig. 105 et 106). Le petit trait au voisinage de chaque figure indique l'échelle de 10μm.

Il est très probable que d'autres espèces de l'ancien genre *Arthrodesmus*, elles que *A. incrassatus* Lagerh., *A. notochondrus* Lagerh., *A. spechtii* Scott et resc., possédant à la fois une inflation médiane ornementée et une seule épine e chaque côté de l'hémisomate, doivent rentrer dans le genre *Bourrellyodesmus*; omme nous n'avons pas vu de matériel de ces espèces, nous nous abstiendrons e proposer ici d'autres nouvelles combinaisons.

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Source MNHN Paris

PREMIER INVENTAIRE DES DIATOMEES MARINES DU LAGON DE TIAHURA (ILE DE MOOREA - POLYNESIE FRANCAISE).

M. RICARD *

RÉSUMÉ. — Au cours de deux missions en Polynésie Française, en juillet 1974 et août 1975, des récoltes de phytoplancton ont été effectuées à la surface du lagon de Tiahura (île de Moorea) au moyen d'un filet à phytoplancton. L'inventaire préliminaire des diatomées de ce lagon et de l'océan environnant est accompagné de mesures quantitatives et de données physico-chimiques. Chaque taxon est assorti de commentaires sur sa fréquence et sa répartition géographique. Les résultats sont comparés avec ceux obtenus dans les lagons de Tahiti.

SUMMARY. — A preliminary list of diatoms collected in two stations at Moorea island (French Polynesia) is given here and its biogeographic composition is discussed. 235 taxa of diatoms have been identified from net samples and some quantitative data are presented : cells counts after sedimentation of water samples, physical and chemical values. Phytoplankton populations in Tahiti and Moorea are compared.

INTRODUCTION

Nous avons effectué, en juillet 1974 et août 1975, deux séjours à l'Antenne du Muséum et de l'Ecole Pratique des Hautes Etudes de Moorea (Polynésie française) afin d'étudier la concentration en pigments chlorophylliens et la productivité primaire des eaux du lagon de Tiahura. A cette occasion nous avons récolté, au filet, le phytoplancton de surface du lagon et de l'océan; ces récoltes ont permis de dresser un premier inventaire taxinomique des diatomées et d'en faire un bilan quantitatif grâce à des prélèvements d'eau. La liste taxinomique est accompagnée de remarques sur la fréquence et la répartition biogéographique de chaque taxon. Les résultats obtenus à Moorea sont comparés à ceux de Tahiti.

I. MATERIELS ET METHODES

A. RECOLTES

Les récoltes ont été réalisées, en surface, au moyen de bouteilles à hydrologie

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Rev. Algol., N. S., 1976, XI, 3-4 : 343-355.

Source MNHN, Paris

de type Van Dorn et de filets à microplancton de vide de maille de 42 μm, traînés à faible vitesse durant 10 minutes à l'arrière d'une embarcation à moteur. Les prélèvements ont été faits dans le lagon puis dans l'océan à 500 mètres environ de la barrière récifale. Les échantillons ont tous été fixés au formol neutre à 4% et conservés 3 à 6 mois avant l'observation. Les échantillons destinés à l'étude qualitative ont été examinés au microscope ordinaire à fond clair après avoir subi un traitement destiné à les nettoyer et à les inclure dans une résine réfringente (RICARD 1975 b). Les comptages quantitatifs ont été réalisés sous un microscope inversé Wild M40 selon la technique décrite par UTERMOEHL (1958).

b. AIRES DE REPARTITION BIOGEOGRAPHIQUES

Les aires de répartition des diatomées et des dinoflagellés sont assez mal définies et chaque auteur donne une signification différente aux termes antérieurement définis ou bien en introduit de nouveaux. DEACON (1933) et HENDEY (1937) parlent de formes antarctiques, subantarctiques et subtropicales, alors que KARSTEN (1907) préfère parler d'espèces ubiquistes, tempérées, tempérées tropicales et tropicales, et STEEMAN-NIELSEN (1939) de formes tropicales et subtropicales. ANGOT (1961) définit les mers tropicales comme celles dont la température ne descend jamais au-dessous de 22° C tout au long de l'année, et SOURNIA (1969) reprend ces définitions ainsi que certains termes utilisés par les auteurs précités dans sa liste taxinomique du phytoplancton du canal du Mozambique (1970)

La nomenclature la plus complète concernant les aires de répartition a été introduite par CUPP (1943) : elle considère des espèces arctiques, boréales tempérées nord, tempérées sud, subtropicales, tropicales et ubiquistes.

Tous les auteurs emploient ces différents termes mais rares sont ceux qui donnent, à l'exemple de DEACON, une définition précise de chaque aire. Les aires de répartition que nous proposons sont au nombre de quatre : arctique antarctique, tempérée, intertropicale; l'aire tempérée est divisée en deux sous aires, tempérée chaude et tempérée froide.

aire arctique et antarctique :

Elles s'étendent d'une part du pôle nord jusqu'à la latitude de 60° N, et d'autre part du pôle sud jusqu'à la latitude de 60° S. Ces deux aires correspondent respectivement aux anciennes aires arctiques et subarctiques, ou antarctiques et subantarctiques.

aire tempérée :

L'aire tempérée froide va des latitudes 60° N ou S aux latitudes 48° N ou S elle correspond, *pro parte*, aux zones boréales et aux zones tempérées Nord ou Sud. L'aire tempérée chaude va des latitudes 48° N ou S aux latitudes 25° N ou S; elle correspond, *pro parte*, aux zones tempérées Nord ou Sud ainsi qu'aux zones tempérées tropicales. Cette subdivision en 2 zones tempérées froide et

Source MNHN, Paris

chaude est plus particulièrement applicable aux mers européennes.

aire intertropicale :

L'aire intertropicale englobe les tropiques du Cancer et du Capricorne et s'étend de la latitude 25° N à la latitude 25° S; cette aire recouvre les anciennes zones équatoriales, tropicales équatoriales, tropicales, ainsi qu'une partie des zones tempérées tropicales.

Cette division en quatre zones est arbitraire dans la mesure où elle ne tient pas compte des courants marins et des convergences océaniques pas plus que des formes de transition entre ces différentes aires, mais permet la distinction entre les taxons endémiques et les taxons cosmopolites. Cette distinction n'est pas réalisée pour les répartitions qui font intervenir les formes de transition, qu'elles soient subtropicales, subantarctiques ou subtempérées. Sans nier l'existence des formes de transition entre les différentes aires de répartition, nous considérons qu'une espèce de transition peut être classée comme appartenant en propre aux deux aires.

Pour chaque taxon nous avons fait une compilation des différents lieux de récolte en nous attachant plus particulièrement aux auteurs ayant travaillé dans les eaux intertropicales des trois océans. Citons plus particulièrement SUBRAHMANYAN (1946, 1958 a et b), SUBRAHMANYAN et SARMA (1960), WOOD (1961 a et b, 1963 a et b) pour l'océan Indien, SILVA (1956, 1960), SOURNIA (1966, 1968 a et b), TRAVERS et TRAVERS (1965), ANGOT (1966) pour Madagascar et le canal de Mozambique, REYSSAC (1966 a et b) pour la Côte d'Ivoire, ALLEN (1937), ALLEN et CUPP (1938), CUPP (1943) pour la côte est des Etats-Unis, GILMARTIN et REVELANTE (1974) pour les Iles Hawaü, DESROZIERES (1969) et HASLE (1959, 1960) pour le Pacifique équatorial.

2. CALCUL DES FREQUENCES DES ESPECES

Sur la liste taxinomique sont indiquées les fréquences respectives de chaque taxon pour les récoltes réalisées dans les lagons, en haute mer et en eau douce. La fréquence s'exprime en pourcentage et correspond au rapport entre le nombre des individus d'un même taxon et le nombre total des individus observés dans la récolte (REYNAUD-BEAUVERIE 1936). La fréquence s'oppose à l'abondance qui est une notion d'appréciation quantitative qui s'exprime en degrés d'abondance allant de 1 à 5.

La fréquence de chaque taxon a été calculée après un comptage effectué sur 1000 individus dénombrés sur 4 lames différentes pour remédier le plus possible à une répartition non homogène des diatomées sur la préparation. Il apparaît expérimentalement qu'il est nécessaire de compter un certain nombre d'individus pour obtenir des fréquences stables : au-delà de 500 individus dénombrés, les fréquences se stabilisent et se répètent si plusieurs comptages sont effectués sur une même récolte, alors que pour des valeurs inférieures ces fréquences oscillent largement. Pour des facilités de calcul et d'écriture nous avons compté

Source MNHN Paris

1000 individus par récolte.

Les fréquences indiquées correspondent aux fréquences cumulées des taxons inventoriés dans tous les lagons de Tahiti et de Moorea, soit 115 récoltes. Nous n'avons pas pris en considération les populations des lagons des îles sous le vent en raison du faible nombre de récoltes.

Nous avons choisi 3 écarts de pourcentage pour définir les fréquences suivantes :

Très fréquent	50 à 100 %	TF
Fréquent	10 à 50 %	F
Rare	0 à 10 %	R
Absent	0 %	(-)

III. RESULTATS

a. COMPOSITION TAXINOMIQUE

L'inventaire qualitatif compte 235 taxons dont 67 diatomées centriques et 168 diatomées pennées qui se répartissent ainsi (cf. Annexe) :

- 69 taxons cosmopolites
- 88 taxons tempérés tropicaux
- 33 taxons tropicaux
- 34 taxons tempérés signalés pour la première fois en milieu tropical
- 2 taxons arctiques et/ou antarctiques

Les diatomées tropicales endémiques représentent 14% de la population globale, les diatomées cosmopolites 30% et les diatomées tempérées tropicales 36%. Ces valeurs correspondent à celles trouvées par SOURNIA à Tuléar (1968) : 11% de diatomées tropicales endémiques, 33% cosmopolites et 35% tempérées tropicales.

La répartition des taxons dans le lagon et l'océan est la suivante :

- 111 taxons (52 centriques et 59 pennées) peuplent à la fois le lagon et l'océan, soit 48% du total.
- 109 taxons (7 centriques et 102 pennées) sont récoltés uniquement dans le lagon, soit 47% du total.
- 14 taxons (12 centriques et 2 pennées) se trouvent seulement dans l'océan, soit 5% du total.

Cette répartition met en évidence la prépondérance des diatomées benthiques dans les eaux du lagon, mais également la forte influence des eaux océaniques qui se traduit par la présence, dans le lagon, de diatomées planctoniques et plus particulièrement de diatomées centriques.

La comparaison entre les populations de Moorea et de Tahiti (RICARD 1970 a et b, 1974, 1975 a et b) accuse la différence de composition qualitative des deux populations : à Tahiti, la part des diatomées pennées représente 84% de la

Source MNHN, Paris

population globale du lagon alors qu'à Moorea elle n'atteint que 73%; inversement, la composition du plancton océanique est la même pour les deux îles à proximité de la barrière récifale : 50% de diatomées centriques et 50% de diatomées pennées. D'autre part la diversité spécifique est plus grande dans les lagons, 227 taxons ont été dénombrés à Moorea et 491 à Tahiti, que dans les prélèvements réalisés à l'extérieur de la barrière, 125 taxons seulement ont été dénombrés à Moorea et 144 à Tahiti où les récoltes ont été pourtant dix fois plus nombreuses.

b. COMPOSITION QUALITATIVE

Les comptages cellulaires au microscope inversé font apparaître une extrême pauvreté numérique du phytoplancton : 1500 à 5600 cellules par litre dans le lagon et 1100 à 2200 cellules par litre dans l'océan. Dans le lagon de Vairao (Tahiti) les valeurs sont légèrement supérieures mais indiquent également une plus forte densité par rapport à l'océan :

La majorité des cellules récoltées dans le lagon appartiennent aux diatomées pennées et aux dinoflagellés cuirassés ou nus, ces deux groupes étant spécifiquement très diversifiés. L'essentiel de la biomasse apparaît constitué de flagellés, en particulier des Coccolithophoridés, et d'algues unicellulaires qui forment le nannoplancton. Leur présence est mise en évidence par des mesures de productivité primaire s'adressant à des échantillons d'eau filtrée ne contenant plus que des cellules de dimensions inférieures à 30 µm : la productivité de ces cellules représente 80% de l'activité photosynthétique totale (SOURNIA et RICARD 1976).

c. PARAMETRES PHYSICO-CHIMIQUES

Au cours des mois de juillet 1974 et août 1975, les valeurs des principaux paramètres physico-chimiques ont été les suivantes :

	- dans le lagon	- dans l'océan
T° (1)	24° à 26° C	25° à 26° C
S‰	36 à 38 ‰	35‰
NO_3 (2)	0.18 à 0.32	0.16
PO_4 (2)	0.18 à 0.21	0.21
SiO_4 (2)	2.02 à 2.70	2.48
O_2 dissous (1)	5.72 à 7.22 ml/l	7.77 ml/l

(1) - Les valeurs de la température et de l'oxygène dissous sont les moyennes des valeurs minimales et maximales relevées au cours de la période diurne.
(2) - les valeurs indiquées sont en µgr. at/litre de N_2, P et Si pour les nitrates, phosphates et silicates.

Source MNHN, Paris

IV. CONCLUSIONS

L'étude de la composition qualitative et quantitative des récoltes réalisées dans le lagon de Tiahura (île de Moorea) met en évidence les faits suivants :

- la diversité spécifique des peuplements de diatomées contraste avec la pauvreté numérique du microplancton et met en évidence le rôle prépondérant du nannoplancton.
- les diatomées récoltées dans les lagons ont peu d'affinité avec le phytoplancton du large en raison de la prépondérance des formes benthiques : cette forte opposition entre le phytoplancton de l'océan et le tychoplancton du lagon caractérise, au même titre que la diversité spécifique, les lagons de Polynésie.
- le rôle de la barrière récifale est prépondérant car, suivant son extension et l'importance du lagon qu'elle détermine, le pourcentage des diatomées planctoniques et benthiques reflète le degré des influences océaniques : à Tiahura (Moorea) le lagon est moins développé qu'à Vairao (Tahiti) et les diatomées planctoniques sont mieux représentées dans les récoltes du lagon.
- les taxons tropicaux endémiques sont peu nombreux par rapport aux taxons cosmopolites ou tempérés tropicaux, mais leur taux semblerait constant dans les récoltes côtières de l'océan Pacifique et de l'océan Indien.

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ANNEXE : LISTE DES TAXONS RÉCOLTÉS A TIAHURA

Diatomées Centriques	Distribution Lagon	Distribution Océan	Répartition Mondiale
Actinocyclus ehrenbergii Ralfs	TF	R	C
Actinocyclus ehrenbergii var. *tenella* (Breb.) Hust.	F	R	C
Actinocyclus subtilis (Greg.) Ralfs	TF	R	C
Actinoptychus senorius (Ehr.) Ehr.	F	R	C
Actinoptychus splendens (Shadb.) Ralfs	R	R	C
Actinoptychus undulatus (Bailey) Ralfs	F	R	C
Arachnoidiscus ehrenbergii Bailey *ex* Ehr.	F	-	T, t
Asterolampra marylandica Ehr.	TF	F	T, t
Aulacodiscus kittoni var. *africano* (Cottam) Rattray	F	R	T, tc
Auliscus coelatus Bailey	-	R	T, tc
Auliscus sculptus (Wm. Smith) Ralfs	-	F	T, t
Bacteriastrum delicatulum Cleve	F	TF	T, t
Biddulphia aurita (Lyngb.) Bréb. *ex* Goddart	TF	R	C
Biddulphia pulchella Gray	-	R	T, t
Biddulphia reticulata Roper	TF	R	T, tc
Biddulphia rhombus (Ehr.) Wm. Smith	R	F	C
Biddulphia titiana (Grunow) Grunow	F	-	T, tc
Biddulphia tuomeyi (Bailey) Roper	F	-	T
Ceratauluis turgidus (Ehr.) Ehr.	-	R	T, t
Chaetoceros atlanticum Cleve	R	TF	C
Chaetoceros compressum Lauder	R	TF	C
Chaetoceros curvisetum Cleve	TF	TF	C
Chaetoceros messanense Castracane	F	TF	T, tc
Chaetoceros peruvianum Brightwell	R	R	C
Chrysanthemodiscus floriatus Mann	TF	R	T, tc
Climacodinium frauenfeldianum Grunow	-	TF	T, tc
Corethron criophilum Castracane	-	R	C
Coscinodiscus centralis Ehr.	R	R	C
Coscinodiscus centralis var. *pacificus* Gran & Angst	-	F	T, t
Coscinodiscus concavus Ehr.	R	-	T, tc
Coscinodiscus excentricus Ehr.	R	F	C
Coscinodiscus jonesianus (Grev.) Ostenfeld	-	R	T, t
Coscinodiscus marginotus Ehr.	R	R	C
Coscinodiscus nitidus Gregory	TF	F	C
Coscinodiscus nodulifer A. Schmidt	F	F	C
Cyclotella meneghiniano Kützing	R	R	C
Ditylum brightwelli (West) Grunow	F	F	T, t
Ethmodiscus appendiculatus (Grunow) Ricard	TF	F	T
Ethmodiscus gazellae (Janish) Hustedt	R	R	T, t
Endictya oceanica Ehr.	F	R	C

Fréquences dans le lagon (col. 1) et dans l'océan (col. 2) : TF : très fréquent; F : fréquent; R : rare; (-) : absent.
Répartition mondiale (col. 3) : C : cosmopolite; T : intertropical; t : tempéré; tc : tempéré chaud; tf : tempéré froid; A : arctique et/ou antarctique.

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Eucampia zoodiacus Ehr.	-	F	C
Hemiaulus hauckii Grunow	R	F	T, t
Hemiaulus sinensis Greville	F	F	T, tc
Hemidiscus cuneiformis Rattray	F	F	T, tc
Hyalodiscus laevis Ehr.	R	R	C
Leptocylindrus danicus Cleve	R	F	C
Melosira dubia Kützing	R	-	C
Melosira sol (Ehr.) Kützing	R	R	C
Planktoniella sol (Wallich) Schütt	-	F	T, t
Podosira hormoides (Montagne) Kützing	-	F	C
Podosira stelliger (Bailey) Mann	F	R	C
Rhizosolenia alata Brightwell *fa alata*	R	F	C
Rhizosolenia hebetata fa semispina (Hensen) Gran	R	F	C
Rhizosolenia imbricata Brightwell *fa imbricata*	F	R	C
Rhizosolenia imbricata var. *shrubsolei* (Cleve) Schröder	F	R	T, t
Rhizosolenia setigera Brightwell	R	R	t
Thalassiosira excentrica Cleve	R	F	T, t
Thalassiosira hyalina (Grunow) Gran	F	R	C
Triceratium alternans Bailey	R	-	C
Triceratium calvescens Castracane	TF	R	T, t
Triceratium dubium Brightwell	F	F	T, tc
Triceratium favus fa quadrata Grunow	-	R	T, t
Triceratium formosum Brightwell *fa formosum*	TF	R	T, t
Triceratium formosum fa quadrangulare (Greville) Hustedt	F	R	T, t
Triceratium reticulum fa hexagonale Ricard	F	R	T
Triceratium shadboltianum Greville	TF	R	T, tc
Triceratium spinosum Bailey	F	-	t

Diatomées pennées

Achnanthes brevipes Agarth	F	-	C
Achnanthes brevipes var. *angustata* (Kütz.) Cleve	F	-	C
Achnanthes citronella (Mann) Hustedt	R	-	T
Achnanthes longipes Agardh	R	R	t
Achnanthes rhombica Oestrup	TF	-	T, t
Amphiprora alata (Ehr.) Kützing	F	R	T, t
Amphiprora gigantea var. *sulcata* (O'Meara) Cleve	R	R	T, t
Amphora acuta var. *arcuata* (A. Schmidt) Cleve	F	-	T, tc
Amphora angularis Gregory	F	-	t
Amphora angustata var. *ventricosa* (Gregory) Cleve	F	-	C
Amphora bigibba Grunow	R	-	T, t
Amphora cingulata Cleve	F	R	T, tc
Amphora coffeaeformis (Agardh) Kützing	F	R	C
Amphora crassa Gregory var. *crassa*	F	F	C
Amphora dubia Gregory	F	-	T, t
Amphora egregia Ehr.	R	R	T, tc
Amphora exigua Gregory	R	R	T, t
Amphora granulata var. *bigibbosa* Ricard	R	-	T
Amphora mexicana A. Schmidt var. *mexicana*	TF	-	T
Amphora obtusa Gregory var. *obtusa*	TF	-	T, t

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Amphora obtusa var. *rectangulata* Peragallo	F	-	T, tc
Amphora ostrearia Bréb. *ex* Kütz. var. *ostrearia*	F	R	C
Amphora staurophora (Castracane) Cleve	R	-	tc
Asterionella glacialis Castracane	F	R	C
Asterionella notata Grunow	R	-	T, t
Auricula complexa (Gregory) Cleve	F	R	T, t
Auricula insecta (Grunow) Cleve	F	R	T, t
Bacillaria paradoxa Gmelin	F	R	C
Caloneis bacillum (Grunow) Meereschkowsky	R	-	t
Caloneis liber (Wm Smith) Cleve	F	-	C
Caloneis silicula (Ehr.) Cleve	R	-	tf
Campylodiscus biangulatus Grevilla	R	-	T, tc
Campylodiscus incertus A. Schmidt	TF	-	T, tc
Campylodiscus innominatus Ross et Abdin	F	-	t
Campylodiscus latus Shadbolt	TF	-	T, tc
Campylodiscus ralfsii Wm Smith	F	-	T, t
Campylodiscus wallichianus Greville	F	-	T, tc
Climacosphenia elongata Bailey	F	-	T, t
Climacosphenia moniligera Ehr.	TF	F	T, t
Cocconeis britannica Naegeli	TF	-	T, t
Cocconeis heteroidea Hantzsch var. *heteroidea*	TF	-	T
Cocconeis pellucida Hantzsch	TF	-	T, t
Cocconeis placentula Ehr. var. *placentula*	F	-	C
Cocconeis scutellum Ehr. var. *scutellum*	R	-	C
Cocconeis vairaensis Ricard	TF	-	T
Cylindrotheca closterium (Ehr) Reiman et Lewin	TF	F	C
Dimeregramma dubium (Grunow) Grunow	TF	R	T, tc
Dimeregramma minor (Gregory) Ralfs	F	-	t
Diploneis bomboides (A. Schmidt) Cleve	TF	F	C
Diploneis bombus Ehr. var. *bombus*	TF	-	C
Diploneis chersonensis (Grunow) Cleve	F	-	C
Diploneis crabro (Ehr.) Ehr. var. *crabro*	F	-	C
Diploneis coffaeiformis (A. Schmidt) Cleve	TF	-	t
Diploneis debyi (A. Schmidt) Cleve	F	-	T, tc
Diploneis fusca (Gregory) Cleve var. *fusca*	F	-	t
Diploneis smithii (Bréb.) Cleve	TF	R	C
Diploneis suborbicularis (Gregory) Cleve	R	R	T, t
Diploneis vacillans var. *renitens* (A. Schmidt) Cleve	R	-	T
Grammatophora gibberula Kützing	R	-	T, t
Grammatophora hamulifera Kützing	TF	R	C
Grammatophora oceanica Ehr. var. *oceanica*	TF	R	T,t
Grammatophora undulata Ehr.	F	-	T
Gyrosigma balticum (Ehr.) Rabenhorst	TF	F	T, t
Gyrosigma elegans Ricard	TF	-	T
Gyrosigma inflatum Ricard	TF	-	T
Gyrosigma gibbosum Ricard	TF	R	T
Gyrosigma spenceri (Wm Smith) Griffith et Henfrey	F	-	tc
Hydrosilicon mitra Brun	F	-	T
Licmophora ehrenbergii (Kütz.) Grunow	F	-	t, A
Licmophora ehrenbergii fa angustata (Grun.) Grun.	F	R	t
Licmophora mediterranea Meereschkowsky	R	R	tc

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Licmosphenia clevei Meereschkowsky	R	-	tc
Licmosphenia peragalli Meereschkowsky	R	-	tc
Mastoglaia achnanthiodes Mann	F	-	T
Mastogloia affirmata (Leuduger et Fortmorel) Cleve	R	-	T
Mastogloia aspera var. *crassa* Ricard	F	-	T
Mastogloia asperulaides var. *angustatissima* Ricard	F	-	T
Mastoglaia baldjickiana Grunow	TF	-	T, t
Mastoglaia binotata (Grunow) Cleve	TF	-	T, t
Mastoglaia citrus Cleve	TF	-	T, tc
Mastoglaia composita Voigt	F	-	T
Mastoglaia corsicana Grunow	TF	-	T, tc
Mastoglaia decussata Grunow	F	-	T
Mastogloia erythrea Grunow	F	-	T, tc
Mastoglaia fimbriata (Brightwell) Cleve	TF	R	T
Mastoglaia horvathiana Grunow	TF	-	T, tc
Mastoglaia inaequalis Cleve	F	-	T, t
Mastoglaia kjelmanii Cleve	F	-	T, tc
Mastoglaia punctatissima (Greville) Ricard	R	-	T, t
Mastoglaia quinquecostata Grunow	F	R	T
Mastoglaia schmidtii Heiden et Kolbe	R	-	T, tc
Mastoglaia undulata Grunow	F	-	T, tc
Navicula clavata Gregory	F	-	C
Navicula cancellata Donkin	R	R	t, A
Navicula cryptocephala Kützing var. *cryptocephala*	F	-	t
Navicula cyprinus (Wm Smith) Boyer	TF	-	t, A
Navicula directa var. *remota* Cleve	F	-	C
Navicula granulata Bailey	TF	-	C
Navicula grevilleoides Hustedt	F	-	T, tc
Navicula langa (Gregory) Ralfs	TF	R	t
Navicula lyra fa typica A. Schmidt	R	-	T, t
Navicula lyroides Hendey	F	-	T, t
Navicula marina Ralfs	F	-	tc
Navicula perobesa A. Schmidt	TF	-	T
Navicula perrhombus Hustedt	F	-	T
Navicula plicatula Grunow	F	-	T, tc
Navicula pseudony Hustedt	F	-	T, tc
Navicula rhombica Gregory	R	-	T, t
Navicula robertsiana fa typica Hustedt	TF	R	T
Nitzschia acuta Cleve	R	-	T, t
Nitzschia amphibia Grunow	R	-	t
Nitzschia angularis Wm Smith	F	-	t
Nitzschia constricta var. *bombiformis* Grunow	TF	F	C
Nitzschia delicatissima Cleve	F	F	t
Nitzschia distans Gregory	F	R	t
Nitzschia graeffii Grunow	F	R	C
Nitzschia majuscula Grunow	TF	-	T, tc
Nitzschia maxima Grunow	F	-	T, t
Nitzschia panduriformis Gregory	F	F	C
Nitzschia seriata Cleve	R	F	C
Nitzschia sigma (Kütz.) Wm. Smith var. *sigma*	F	R	C
Nitzschia sigma var. *intercedens* Grunow	F	R	C

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Nitzschia spathulata Brébisson	F	R	C
Nitzschia ventricosa Palmer	TF	R	T, tc
Opephora pacifica (Grunow) Petit	F	R	T
Plagiogramma atomus Greville	F	-	T, tc
Plagiogramma interruptum (Gregory) Ralfs	R	-	T, tc
Plagiogramma staurophorum (Greg.) Heiberg	TF	-	C
Pleurosigma angulatum (Quekett) Wm Smith	F	R	t
Pleurosigma decorum Wm Smith	R	-	C
Pleurosigma formosum Wm Smith	F	F	C
Pleurosigma itium Ricard	R	-	T
Pleurosigma longum Cleve	F	-	t, A
Pleurosigma rigidum Wm Smith	TF	F	T, t
Pleurosigma tahitianum Ricard	R	-	T
Podocystis adriatica (Kütz.) Ralfs	R	-	T, t
Podocystis spathulata (Shadbolt) Van Heurck	TF	R	T, tc
Progonaia musca (Gregory) Schrader	F	R	C
Pseudoeunotia doliolus (Wallich) Grunow	R	R	T, tc
Rhabdonema adriaticum Kützing	TF	F	C
Rhabdonema punctatum (Harvey et Bailey) Stodder *ex* Boyer	R	-	T, tc
Rhaphoneis amphiceros var. *tetragona* Grunow	F	-	T
Rhoicosigma antillarum Cleve	TF	R	T
Sceptroneis peragalli (Leud et Fort.) Meister	F	R	T
Stauroneis polynesiae (Brun) Hustedt	TF	-	T
Stauroneis salina Wm Smith	F	-	t
Surirella fastuosa Ehr. var. *fastuosa*	TF	F	T, t
Surirella fastuosa var. *cuneata* (A. Schmidt) Per.	TF	F	t
Surirella martensiana (Grun.) Peragallo	F	R	T
Surirella reniformis Peragallo	F	R	T, tc
Synedra crystallina (Ag.) Kütz. var. *crystallina*	TF	-	t
Synedra laevigata Grunow var. *laevigata*	TF	-	T, tc
Synedra robusta Ralfs	R	-	T, tc
Synedra ulna (Nitzsch) Ehr.	F	R	C
Synedra undulata Bailey	TF	R	T, tc
Synedrosphenia gomphonema (Jan. et Rab.) Hustedt	F	R	T, tc
Thalassionema nitzschioides Grunow	R	F	C
Thalassiotrix frauenfeldii Grunow	-	F	C
Thalassiotrix mediterranea var. *pacifica* Cupp	-	F	tc
Trachyneis aspera (Ehr.) Cleve var. *aspera*	TF	R	T, t
Trachyneis velatoides Ricard	F	R	T
Tropidoneis lepidoptera (Greg.) Cl. var. *lepidoptera*	TF	F	T, t
Tropidoneis maxima var. *subalata* Cleve	F	R	T, t
Tropidoneis maxima (Gregory) Cleve	TF	F	T,t

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ANALYSES BIBLIOGRAPHIQUES

P. BOURRELLY

BOURRELLY, P. — Quelques algues d'eau douce de Guinée. *Bull. Mus. Nat. Hist. Nat.* 3e sér., nº 276, Bot. 20 : 1-72, 11 pl.

L'étude de quelques récoltes de Guinée permet de reconnaître 220 taxons d'algues d'eau douce (Diatomées exclues). Les Desmidiées, avec 144 taxons sont les formes dominantes. Cinq nouveautés des genres *Euastrum, Micrasterias, Staurodesmus,* et *Staurastrum* sont décrites. L'élément tropical est représenté par 80 taxons. Des notes de systématique critique et une abondante iconographie complètent ce travail.

CASPER, S.J. — Grundzüge eines natürlichen Systems der Mikroorganismen. G. Fischer Ed., Iena, 1974, 1 vol., 1-232, 42 fig., 34 tabl.

Dans ce volume d'une conception très originale, l'auteur fait une synthèse de nos connaissances sur les organismes microscopiques végétaux et animaux : c'est-à-dire les Bactéries, les Algues, les Champignons, les flagellés incolores, les Protozoaires. Il étudie 28 exemples types et s'attache particulièrement à l'ultrastructure des flagelles et à la cytologie fine des organismes.

Il aboutit ainsi à une classification très proche de celle qui est actuellement admise mais avec une terminologie de Zoologiste, et non de Botaniste.

Ce livre, sous une forme réduite, présente une documentation extraordinaire. La bibliographie occupe 26 pages, elle est très complète, avec cependant quelques petites lacunes sur les procaryotes. Même si on ne partage pas les conceptions de l'auteur, cet ouvrage rendra de grands services : c'est une véritable mine de renseignements. Citons particulièrement les 34 tableaux qui résument, de façon très didactique, les caractères des Microorganismes (pigments, réserves, types des plastes, type de flagelles, etc...).

Grâce à cet ouvrage, le lecteur aura une vue d'ensemble très précise sur le monde microscopique et il faut remercier son auteur de nous faire part de son érudition.

CORILLION, R. — Flore des Charophytes (Characées) du Massif Armoricain et des contrées voisines d'Europe occidentale. *In* Flore et Végétation du Massif Armoricain, Jouve Ed., Paris, 1975, t. IV, 1 vol. : 1-216, 18 cartes, 16 pl.

Ce volume soigneusement présenté fait partie de la Flore du Massif Armoricain préparée par H. des ABBAYES. Le Massif Armoricain renferme 15 espèces

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de *Chara*, 1 de *Lamprothamnion*, 1 de *Nitellopsis*, 10 de *Nitella* et 6 de *Tolypella*.

De plus l'auteur décrit en appendice les Characées françaises non rencontrées en Bretagne (1 de *Lychothamnus*, 1 *Nitella*, 1 *Tolypella*) : ainsi le lecteur a, sous un format pratique, une véritable flore des Charophytes de France. L'ouvrage n'est d'ailleurs pas simplement une flore, mais une étude simple et très complète de ces algues. Une trentaine de pages est consacrée aux généralités : écologie, distribution géographique, morphologie, cytologie. Les lecteurs non spécialistes apprécieront le glossaire des termes descriptifs particuliers aux Characées. 18 cartes montrent la distribution des taxons dans le Massif Armoricain. La partie analytique des espèces, avec des clefs de détermination, figures abondantes, variétés, écologie, constitue en 120 pages le corps de l'ouvrage. Le lecteur trouvera des renseignements précis sur le nombre chromosomique, un tableau des caractères comparés des organes reproducteurs, un abrégé phylogénétique, un historique, etc.

Cette rapide énumération montre l'intérêt de cet ouvrage, qui est à la fois simple, précis et complet. Sa présentation très claire, ses illustrations originales, en font un instrument de travail fort pratique qui fait honneur à son auteur, et qui permettra à tous les botanistes, même non spécialisés, de pouvoir déterminer toutes les Characées de la Flore française.

CORILLION, R. et GUERLESQUIN, M. — Recherches sur les Charophycées d'Afrique occidentale, systématique, phytogéographie et écologie, cytologie, *Bull. Soc. Sc. Bretagne* 1972, 47 : 1-169, 18 pl. 23 phot.

Ce mémoire étudie les Characées de Mauritanie, Sénégal, Mali, Côte d'Ivoire, Guinée, Togo et Ghana. Il est composé de trois parties : Systématique, Ecologie et Phytogéographie, Cytologie.

Dans le chapitre systématique nous trouvons 15 taxons de *Chara*, et 15 de *Nitella* (dont une nouvelle espèce). Toutes les unités systématiques sont décrites en détail et l'illustration originale est abondante (8 planches et 23 photos).

Dans ce chapitre figurent aussi des précisions sur l'écologie, la phytosociologie et la distribution géographique. Des clefs de détermination très précises complètent cette mise au point.

La deuxième partie traite de la phytogéographie et de l'écologie et présente les associations intertropicales des Characées africaines et leur relation avec les autres groupements d'hydrophytes. 22 cartes montrent les répartitions africaines et mondiales des espèces les plus remarquables.

La dernière partie est une étude des nombres chromosomiques de 9 taxons de *Nitella* et de 2 de *Chara* accompagnée de 10 planches et de 3 cartes de répartition géographique des diverses lignées chromosomiques.

Une bibliographie très complète, un index, un vocabulaire terminent ce travail.

L'un des auteurs, R. CORILLION, a déjà publié un ouvrage désormais classique : «Les Charophycées de France et d'Europe occidentale». Le présent mémoire le complète en quelque sorte, en l'étendant sur une partie de l'Afrique dont la végétation charologique était mal connue.

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DROUET, Fr. — Revision of the *Nostocaceae* with cylindrical trichome (formely *Scytonemataceae* and *Rivulariaceae*). Hafner Press, 1973 : 1-292, 83 fig.

Voici le troisième ouvrage monographique de l'auteur sur les Cyanophycées, ouvrage encore plus explosif et plus déroutant que les précédents.

Il étudie ici les *Nostocales* des familles des Scytonematacées, Rivulariacées et Microchaetacées, et quelques genres des Borzinématacées à trichomes non toruleux.

Pour l'auteur, forme du thalle, type de ramification, présence ou absence de gaines ou d'hétérocystes, sont des caractères sans valeur systématique et sous l'unique dépendance des conditions du milieu. Le seul critère valable est donné par la forme de la cellule végétative terminant le trichome. Les coupures génériques se font ainsi :

1) cellule terminale hémisphérique devenant presque sphérique : *Scytonema*.
2) cellule terminale d'abord hémisphérique puis conique, obtuse ou cylindrique à pointe arrondie : *Calothrix*.
3) cellule terminale d'abord hémisphérique puis plus ou moins conique aigüe : *Raphidiopsis*.

Ainsi ce grand ensemble qui groupait jusqu'alors 15 genres et près de 300 espèces est réduit à 3 genres et 4 espèces.

Le genre monospécifique *Scytonema* tel qu'il est défini renfermera sous le nom unique de *Scytonema hofmannii* aussi bien les *Scytonema* vrais que les *Tolypothrix, Plectonema* sans hétérocyste, les *Desmonema*, et même les *Handeliella* à ramification véritable du type *Stigonema*. Par contre *Scytonematopsis* est placé dans les *Calothrix*. Le genre *Calothrix* avec deux espèces, l'une pour les eaux douces (*C. parietina*) et l'autre (*C. crustacea*) pour les eaux marines, groupe *Rivularia, Aphanizomenon, Microchaete, Aulosira, Homeothrix, Gloeotrichia* etc... Ainsi *Rivularia haematites, Gloeotrichia natans, Homeothrix juliana* et *Anabaena unispora* par exemple appartiennent tous à l'espèce *Calothrix parietina*. De même tous les *Rivularia* marins, *Microchaete grisea, Richelia intracellularis* et *Kyrtuthrix dalmatica* portent le même nom de *Calothrix crustacea*. Quant au genre monospécifique *Raphidiopsis* il s'accroît des *Anabaenopsis* à hétérocystes apicaux terminaux coniques et des *Aphanizomenon* à apex très effilés car l'auteur indique dans sa diagnose la présence d'hétérocyste, caractère non signalé par FRITSCH et RICH, inventeurs du genre.

L'ensemble de ce travail, solidement documenté par une investigation très poussée des échantillons d'herbiers du monde entier, bouleverse entièrement la systématique classique. Malheureusement, à notre avis, il est fondé non sur une expérimentation convaincante, mais sur le postulat des «écophènes» qu'il faut accepter sans preuves réelles. Nous n'ignorons pas l'importance du polymorphisme des Cyanophycées et de ses relations avec le milieu, cependant nous n'admettons pas sans preuves suffisantes les conclusions de l'auteur pour qui tout est écophène. Ainsi il est impossible d'admettre que *Aphanizomenon flos aquae* soit un *Microcoleus vaginatus* et que sa variété *gracile* soit un *Calothrix parietina*. De même il est curieux que *Microchaete tenera* soit un *Scytonema* tandis que *M. grisea* et *M. diplosiphon* sont deux *Calothrix*.

Enfin du point de vue nomenclatural nous comprenons mal pourquoi le nom

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Calothrix Agardh 1824 est préféré à celui de *Rivularia* Roth. 1797 (ou mieux 1802-1806). De même le type de *Scytonema* nous semble être *Sc. myochrous* (Dillwyn 1802) Agardh 1812 et non *hofmannii* Agardh 1817.

A notre grand regret, nous ne pouvons accepter cette nouvelle nomenclature qui par sa simplification excessive et arbitraire conduit à donner le même nom à des organismes très différents et de ce fait rend impossible toute étude floristique ou écologique. Malgré ces critiques, cet ouvrage rendra de grands services par sa bibliographie et son index particulièrement exhaustif.

GAYRAL, P. — Les algues, morphologie, cytologie, reproduction, écologie. Doin Ed., Paris, 1975 : 1-166, 84 fig.

Cet ouvrage, destiné aux étudiants, est un modèle de clarté et de précision. Dans un texte relativement court, l'auteur fait une synthèse de nos connaissances sur le grand monde des algues.

Le plan suivi : 1) généralités, avec morphologie, cytologie et reproduction.
2) caractères des grands groupes d'algues.
3) quelques aspects de l'écologie et de la physiologie des algues : phytoplancton et algues non planctoniques.

montre bien que tout le domaine de l'algologie est abordé.

Un glossaire, un index alphabétique, un tableau synoptique des algues (jusqu'à l'ordre), de nombreux schémas, en font un travail d'une haute valeur, tant pédagogique que scientifique.

Ce livre qui rendra de grands services aux étudiants et à leurs maîtres, intéressera aussi les algologues spécialisés car il donne une vue d'ensemble moderne et bien documentée sur les algues qu'elles soient micro- ou macroscopiques, marines ou dulçaquicoles.

Cet ouvrage démontre de façon très nette qu'on peut être à la fois bon chercheur et excellent professeur.

KALBE, L. — Kieselalgen' in Binnengewässern. Die neue Brehm Bücherei, 1973 467 : 1-206, 37 pl.

L'auteur, diatomiste bien connu, nous donne un petit livre sur les Diatomées d'eau douce qui est une synthèse très complète de nos connaissances sur ces algues.

La moitié du livre est consacrée à la structure, la reproduction et l'écologie des Diatomées. Tous les problèmes posés par l'étude de ces organismes sont traités, brièvement, mais avec précision. Nous y trouvons aussi bien des renseignements sur la préparation, le montage des Diatomées que sur le dessin, la microphotographie ou le comptage. La partie écologique de 50 pages renferme des listes d'espèces caractéristiques hallobiontes et saprobiontes.

La dernière partie donne, suivant la systématique classique, une brève diagnose de chaque genre de Diatomées et est complétée par 465 figures groupées en 37 planches représentant les formes les plus communes. Pour chaque figure, le nom d'espèce est accompagné de renseignements écologiques. Chaque chapitre possède une bibliographie très complète. Le livre se termine par un double index : matière et noms des espèces.

En conclusion un petit volume, bien documenté, bien présenté, qui est une

Source MNHN, Paris

excellente initiation à la connaissance des Diatomées dulçaquicoles.

KOMAREK, J. – The morphology and taxonomy of Crucigenioid algae (Scenedesmaceae, Chlorococcales). *Arch. Protistensk.* 1974, 116 : 1-75.

L'auteur présente une étude des Chlorococcales autosporées à cénobes plats fondée sur le mode de division lors de la formation des autospores.

Grâce à de nombreuses cultures et à l'étude du matériel sauvage, l'auteur reconnaît deux grands types de division : 1° - l'orientation de la croix dessinée par les 4 autospores est identique à celle des 4 cellules du cénobe paternel. 2° - l'orientation de cette croix lors de l'autosporulation fait un angle de 45° avec les branches de la croix formée par les cellules du cénobe paternel. Dans le premier type se place les genres : *Tetrastrum, Crucigeniella, Willea, Westella* et *Tetrachlorella*. Dans le deuxième type on trouve : *Crucigenia* et *Hofmania*.

L'auteur donne une étude monographique de tous ces genres et une description de toutes les espèces. Le genre *Crucigeniella* Lemm. est repris pour les anciennes espèces *Crucigenia rectangularis, lunaris, truncata, apiculata, pulchra, crucifera* et *neglecta*. De même le genre *Willea* Schmidle est ressuscité pour *Crucigenia irregularis* Wille et *Dispora vilheimii* Fott. Cet intéressant mémoire présente de nombreuses nouvelles combinaisons et donne un aperçu sur la phylogénie possible de la famille des Scenedesmacées. Une très importante illustration de 102 figures complète cette belle monographie.

LEE, K.W. et BOLD, H.C. – Phycological studies 12. *Characium* and some *Characium* like Algae. *Texas Publ.* 1974, 7403,: 1-127.

Ce travail très intéressant est fondé sur des cultures d'algues. Les auteurs y étudient 10 espèces de *Characium* (dont 8 nouvelles espèces) une nouvelle espèce de *Pseudocharacium* à zoospore quadriflagellée, une nov. sp. d'*Ankyra* à trois épines, parmi les algues vertes chlorococcales. De plus une Tétrasporale, nouvelle espèce de *Characiochloris*, est décrite. Enfin, les auteurs donnent quelques compléments sur deux Xanthophycées des genres *Characiopsis* et *Pseudocharaciopsis*.

Pour chacune de ces espèces on trouve une étude morphologique et taxinomique accompagnée d'une étude physiologique portant surtout sur la nutrition de ces algues. Signalons aussi le chapitre sur la fixation des zoospores qui montre que chez quelques espèces de *Characium*, la zoospore se fixe non par le pôle apical, mais par le pôle postérieur, après rotation de la cellule accrochée d'abord par ses flagelles.

L'illustration, très abondante, comprend 223 figures. Malheureusement il s'agit le plus souvent de photographies qui ne permettent pas, comme un bon dessin, d'avoir une idée précise de la morphologie de ces algues.

MARGALEF, R. – *Ecologia*. Omega Ed., Barcelona, 1974 : VII-XV, 1-951.

Voilà un livre impressionnant par son volume et par l'ampleur du sujet : l'écologie. Après un rappel historique sur la naissance de cette discipline, l'auteur traite l'écologie sous tous ses aspects dans sept chapitres consacrés au milieu, à la biogéographie, à l'écologie descriptive, à l'écologie trophique, à l'écologie démographique, à l'écosystème dans le temps et à l'écosystème dans l'espace. L'ouvrage se termine par un chapitre de synthèse dans lequel l'auteur donne une conclusion pour chacun des chapitres précédents. Chaque chapitre est abondamment

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illustré de planches et de graphiques et se termine par une bibliographie très complète.

Cet ouvrage est certainement le plus intéressant et le plus complet de tous ceux qui ont été consacrés, à ce jour, à l'écologie et sera par conséquent d'une aide précieuse aussi bien aux écologistes avertis que débutants.

MOLLENHAUER, D. — Erstes Internationales Desmidiaceensymposium, Bieber (Spessart) Sept. 1971. *Beih. Nov. Hedwigia* 1975, 42 : 1-316.

L'auteur a organisé le premier symposium international sur les Desmidiales, et il nous présente les comptes-rendus de cette réunion qui groupait 17 spécialistes. Tous les sujets ont été abordés : nomenclature (ANDRESEN, BICUDO), cycle de vie (BIEBEL), cytologie et ultrastructure (CHARDARD, DOBBERSTEIN, GERRATH), sexualité (DUBOIS-TYLSKI, KIES, LENZENWEGER, LIPPERT, GERRATH), caryologie (KASPRIK), rapport entre ultrastructure des membranes et systématique (MIX), polymorphisme et systématique (RUZICKA) cultures synchrones (SCHULLE), sociologie et écologie (TASSIGNY), formation des Chlamydospores (LHOSTKY). L'organisateur, après une introduction rappelant le vaste champ d'études offert par les Desmidiées, donne une communication très documentée sur la phylogénie des Zygnématales. Ce coup d'oeil trop rapide, suffira cependant à montrer l'intérêt et la richesse de ce beau volume soigneusement illustré. Espérons et souhaitons que ce premier symposium aura une descendance nombreuse et remercions MOLLENHAUER de son initiative.

NOVA SCOTIA RESEARCH FOUNDATION — Selected bibliography on algae. *Nov. Scotia res. Found. Darthmouth* 1973, 14 : 1-200.

Voici, malheureusement, le dernier fascicule de cette intéressante publication bien connue de nos lecteurs. Ce dépouillement bibliographique est fort bien fait, les travaux principaux y sont cités et signalons la part importante qui est donnée à la «pratique», cultures des algues, utilisations médicales, alimentaires, industrielles, etc... dont la bibliographie est souvent négligée.

STARMACH, K. — *Cryptophyceae, Dinophyceae, Raphidophyceae. Flora Slodkowdna Polski* 1974, 4 : 1-519.

Voici le 12e volume de l'œuvre monumentale du Pr. STARMACH. Il offre les mêmes qualités de présentation et de clarté que les précédents. Dans les trois grands groupes étudiés, une série de clefs dichotomiques permet d'arriver à l'espèce. Pour chaque espèce la diagnose est complétée par une ou plusieurs figures et par la répartition géographique. Une bibliographie accompagne chaque groupe. La systématique suivie est celle de notre ouvrage (Algues d'eau douce, 3, 1970).

Signalons que l'auteur indique quelques espèces de la Baltique (parmi les Dinophycées). L'illustration très abondante, 643 figures, rendra de grands services au lecteur ignorant la langue polonaise.

TUPA, D.D. — An investigation of certain Chaetophoralen Algae. *Beih. Nov. Hedwigia* 1974, 46 : I-V, 1-155, 291 fig.

Cet important travail est consacré à la systématique de certaines Chlorophycées Chaetophorales d'eau douce. L'auteur, uniquement à l'aide de cultures, é-

Source MNHN Paris

tudie de nombreuses espèces des sept genres suivants : *Protoderma, Gongrosira, Pleurastrum, Microthamnion, Pseudendoclonium, Chamaetrichon* et *Aphanochaete*. Il s'agit d'algues épiphytes ayant toutes, à l'exception de *Microthamnion*, un thalle prostré à leur base. Une série de tableaux met en évidence les caractères taxinomiques de tous les genres de *Chaetophorales* ainsi qu'une analyse historique critique.

L'auteur, avec PRINTZ, place les espèces dulçaquicoles d'*Ulvella* parmi le genre *Protoderma*. De même le genre *Pleurothamnion* Borzi est donné comme synonyme de *Gongrosira*. Le genre *Pleurastrum*, très proche de *Gongrosira*, dont seul l'aspect piriforme de la zoospore l'en sépare, groupe entre autres les *Leptosira* à pyrénoïde et le *Rheximena paucicellulare*. Le nouveau genre monospécifique, *Chamaetrichon*, à thalle entièrement prostré, possède des zoospores quadriflagellées : c'est la grande différence avec *Protoderma*. Une étude physiologique termine ce mémoire.

Ce travail bien documenté rendra de grands services aux systématiciens : l'illustration photographique, fondée sur des cultures, est fort intéressante, mais il est dommage qu'elle ne soit pas complétée par une documentation sur le matériel «sauvage».

WUTHRICH, M. – Contribution à la connaissance de la flore algologique du Parc National Suisse : Les Diatomées. *Result. Rech. Sc. Parc Nat. Suisse* 1975, 14, 72 : 273-369.

Comme le remarque, avec ironie, l'auteur, le guide scientifique du Parc National Suisse (1966) indique que 558 plantes sont connues dans ce parc, avec seulement une dizaine d'espèces d'algues; le guide ajoute : «Si l'on compare la flore des algues du Parc avec celle des plantes à fleurs, la différence la plus frappante réside dans le nombre restreint des espèces composant la première, dont quelques unes seulement ont été citées, comparée à la grande richesse en espèces des phanérogames de la région...». L'auteur, après étude d'un petit nombre de stations, signale, simplement pour les Diatomées, 468 taxons répartis en 36 genres. Elle décrit 4 taxons nouveaux appartenant aux genres *Achnantes, Anomoeoneis* et *Pinnularia*. 41 plantes groupant plus de 450 dessins originaux illustrent ce beau travail. Le lecteur y trouvera des remarques de systématique critique et des notes sur l'écologie et la chimie des eaux. Un beau mémoire dont la finesse des figures comblera d'aise les Diatomistes.

YACUBSON, S. – Catalogo e iconografia de las Chlorophyta de Venezuela. *Bol. Centr. investig. biol. Univ. Zulia* 1974, 11 : 1-143.

L'auteur qui a déjà publié un catalogue des Cyanophytes du Vénézuéla, (voir *Rev. Alg.* XI, 1/2 : 202), nous donne aujourd'hui, avec une illustration de 436 figures groupées en 31 planches, la catalogue des 434 Chlorophycées d'eau douce signalées dans son pays. Les Desmidiacées s'y taillent la part du lion et y occupent 35 pages du texte et 22 planches. Pour chaque espèce, figure une illustration et le lieu des récoltes, ainsi que les auteurs qui ont signalé l'espèce.

Ce travail rassemble ainsi, sous un faible volume, toute l'iconographie consacrée aux Chlorophycées du Vénézuéla. Un excellent ouvrage qui permettra maintenant de prospecter en profondeur ces eaux si riches en algues.

Source MNHN, Paris

KOMAREK, J. — Taxonomic review of the genera *Synechocystis* Sauv. 1892, *Synechococcus* Näg. 1849 and *Cyanothece* gen. nov. (Cyanophyceae). *Arch. Protistenk.* 1976, 118 : 119-179.

A l'aide de matériel «sauvage» pris dans la nature et de culture l'auteur étudie 3 genres de *Chroococcales* unicellulaires, solitaires le plus souvent. La forme des cellules et le processus de division permet de séparer :

1 - *Synechocystis* à cellules globuleuses solitaires se divisant successivement suivant deux plans perpendiculaires (comme chez *Merismopedia*).

2 - *Synechococcus* à cellules allongées, ellipsoïdales ou cylindriques se divisant toujours par un plan perpendiculaire au grand axe en cellules filles souvent de taille inégale.

3 - *Cyanothece*, nouveau genre créé pour les cellules ellipsoïdales, presque globuleuses, toujours solitaires et se divisant toujours en 2 cellules filles identiques et suivant un plan perpendiculaire au grand axe.

Synechocystis groupe 17 espèces.

Les genres *Rhabdoderma* Schm. et Lauterb., *Raciborskia* Koczw., *Romeria* Koczw., *Amalia* De Toni, *Chroobacter* Pringsh. et *Lauterbornia* Pringsh. sont placés dans le genre *Synechococcus* Näg. qui renferme 39 espèces dont certaines forment de courts filaments irréguliers, d'un petit nombre de cellules, parfois enrobés dans une gelée homogène. On trouve dans ce genre ainsi défini, entre autre le célèbre «Anacystis nidulans» dont les cultures ont fait l'objet de nombreux travaux de physiologie et de biochimie.

Enfin le nov. gen. *Cyanothece*, avec comme espèce type *C. aeruginosa* (= *Synechococcus aeruginosus* Näg.) réunit 10 espèces.

Cette étude est une monographie très complète et pour chaque espèce sont données une diagnose, une répartition géographique et une série de figures. 8 tableaux précisent les caractères des espèces, suivant les différents auteurs. L'illustration, abondante et soignée, groupe 130 figures où sont toujours reproduites les figures originales des premiers descripteurs.

Nous ferons un petit reproche à ce travail : l'absence de clefs de détermination, clefs qui auraient facilité la tâche du systématicien. Un travail remarquable qui met enfin un peu d'ordre dans un groupe très difficile où les caractères systématiques sont rares.

SKUJA, H. — Zur Kenntnis der Algen Neuseeländischer Torfmoore. *Nov. Act. Reg. Soc. Sc. Upsal. Ser.* V : C, 1976, vol. 2 : 1-159.

Il s'agit d'un mémoire posthume du grand algologue décédé en 1972 et dont K. THOMASSON a publié la biographie dans la *Rev. Algol.* vol. 11, 2. L'auteur étudie les algues microscopiques de quelques tourbières acides de Nouvelle Zélande : 11 récoltes de l'île du Nord et 8 récoltes de l'île méridionale. Il s'agit d'un travail systématique portant sur un ensemble de 389 espèces et 64 variétés. Les Zygophycées (ou Conjuguées) occupent la première place avec 237 taxons, puis viennent les Diatomées : 104 unités systématiques. Les autres groupes d'algues sont plus faiblement représentés : 32 Cyanophycées, 9 Euglénophycées, 7 Chrysophycées, 4 Xanthophycées. Comme dans toutes les tourbières acides, les Chlorococcales, avec 27 espèces, sont peu abondantes.

L'île du Sud avec 445 taxons dépasse largement l'île du Nord : 290 taxons.

Source MNHN Paris

Parmi les Desmidiées, algues préférentielles des eaux acides, le genre *Cosmarium* (88 taxons) est dominant; il est suivi par *Euastrum* (30) et *Closterium* (30) puis par *Staurastrum* (25). Dans les Diatomées, la première place revient à *Pinnularia* (24 taxons), puis viennent *Eunotia* (15), *Cymbella* (11) et *Navicula* (11).

A côté de nombreuses algues acidophiles des régions tempérées, on rencontre un élément tropical important surtout parmi les Desmidiées et les Diatomées.

Comme il était facile de le prévoir, les nouveautés systématiques sont nombreuses : nous avons dénombré 16 sp. nov., 21 var. nov. et 2 nov. comb. Ces taxons nouveaux se rencontrent dans les genres *Anabaena, Hormidium, Zygogonium, Zygnemopsis, Zygnema, Closterium, Pleurotaenium, Cosmarium* (4 nov. sp. et 7 var. nov.), *Arthrodesmus, Xanthidium, Euastrum, Micrasterias, Staurastrum, Spondylosium, Desmidium* et *Lagynion*. Comme on le voit, là aussi les Conjuguées tiennent la première place.

L'auteur est peu favorable aux innovations systématiques : ainsi il conserve le nom d'*Hormidium* (en citant cependant *Chlorhormidium*); il n'accepte pas le genre *Staurodesmus* proposé si heureusement par TEILING, et conserve à *Arthrodesmus* ses limites anciennes. Il utilise encore *Gymnozyga* au lieu de *Bambusina* et *Ankistrodesmus* pour *Monoraphidium*...

Cette analyse systématique est accompagnée pour de très nombreux taxons, de remarques et de commentaires très importants. Ainsi il consacre une longue discussion au genre *Zygogonium* et montre clairement que le genre *Pleurodiscus* n'est qu'un synonyme du précédent.

Comme pour tous les travaux de SKUJA il faut signaler la beauté, la précision et l'abondance des illustrations. Le volume se termine par une série de 16 planches vraiment merveilleuses qui groupent près de 300 figures.

Ce mémoire est précédé d'une courte préface biographique écrite par T. WILLEN et ornée d'une photographie de SKUJA. Comme tous les ouvrages de ce grand algologue, ce mémoire prendra place parmi les classiques de l'algologie d'eau douce.

SOUTH, G. R. et CARDINAL, A. — Contributions to the flora of marine algae of Eastern Canada. 1. Introduction, historical review and key to the genera. *Natural. Canad.* 100 : 605-630.

Après un rapide historique de l'algologie marine des côtes de l'Est canadien, les auteurs, dont l'un a déjà dressé un catalogue des algues benthiques de cette région, présentent une clef de détermination des genres de Chlorophycées (37 gen.), Phéophycées (61 gen.) et Rhodophycées (70 gen.) recueillies sur les côtes canadiennes. Une abondante bibliographie complète cette utile mise au point.

Source MNHN Paris

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Source MNHN Paris

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